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THE TREATMENT OF OSTEOMYELITIS (INFECTION OF BONE) WITH FLY LARVÆ.*

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AND
E. HARLAND WILSON.

The disease known to medicine as osteomyelitis is an infection of the bone and adjacent tissues which frequently becomes chronic, often results in crippling deformities and sometimes proves fatal. The usual method of treatment is surgical, involving the removal of dead bone and the attempted elimination of infected areas. Because of the site and nature of the involvement, surgical treatment alone often fails and repeated operations are frequently required.

In 1917, during the World War, the late Dr. Wm. S. Baer of Baltimore, Md., serving with the American Army in France, noted that some of the soldiers brought to the hospital from the battle field with compound fractures of the thigh, had wounds heavily infested with maggots. Contrary to expectation, their general condition and that of the wounds seemed markedly better in contrast with others not showing such infestation. Furthermore, those with maggots seemed to recover in a shorter time (Baer, 1930). With these observations in mind, Dr. Baer returned to America and some ten years later decided to try the introduction of maggots into civil practice as a treatment in stubborn cases of osteomyelitis. His clinical studies were carried on for the most part at the Children's Hospital School in Baltimore.

The first treatments were made with maggots secured from natural sources. However, it soon became apparent that this was attended by certain dangers, inasmuch as fly larvæ in

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nature live along with microorganisms that are pathogenic to man. Therefore, the direct implantation of maggots by the surgeon in an open wound would be justified only after two important questions had been satisfactorily answered. (1) Do maggots assist in the process of healing? (2) Can they be released for activity without danger of inciting further disease complications? The first of these questions was at least suggestively answered in the affirmative by Dr. Baer's observations during the war and his preliminary peacetime studies. It then became necessary to seek a satisfactory answer to the second question. The rearing of bacterially sterile maggots is but one of the many problems which have been under study during recent months in several centers, notably at the Children's Hospital School in Baltimore, the United States Naval Medical School in Washington, D. C., and the Ohio State University, Columbus, Ohio.

A COOPERATIVE PROJECT.

For many years cultures of blowflies of various types have been grown in the Department of Zoology and Entomology at the Ohio State University for purposes of studying insect physiology, behavior and rearing methods. During the summer of 1930 one of us (D. F. M.) worked with the United States Bureau of Entomology at Washington, D. C., upon the problem of rearing flies for clinical use. Since October of that year the study has been continued at the Ohio State University as a cooperative project between the Department of Zoology and Entomology, the Department of Medical and Surgical Research, and the Department of Orthopedics. This arrangement makes possible a complete series of studies beginning with the rearing of the flies and ending with the treatment of selected patients in the hospital.

REARING OF FLIES.

Several articles giving methods of maintaining cultures of flies have appeared recently, particularly those of Elizabeth K. Elgin at the Children's Hospital School (Baer, 1930–1931) and that from the Naval Medical School by Murdock and Smart (1931). While the methods employed and described by the above writers show the feasability of cultivation of larvæ for clinical purposes, much is yet to be learned concerning the factors of food, temperature, humidity, light and efficiency in

handling. These problems have been and are now under study at the University and the following information is a preliminary report of our experiences and results during the past year.

Our work has been restricted largely to the two species of blowflies *Lucilia seracata* and *Phormia regina*. These are two of our more common blowflies, easily obtained, easily reared in captivity and are the two that have been most generally used so far in the clinical work of others.

Cages.—The size and shape of culture cages is largely a matter of convenience. We use cages of about one cubic foot capacity because of ease in handling and cleaning. In cages of this size it has been found that a population in excess of 200 to 250 flies gives signs of overcrowding. Gauze or cheese cloth is to be preferred to wire screen as a covering for the cage. The flies in screen cages are more easily disturbed by objects moving near the cage, such excitement resulting in broken wings and a decrease in egg laying. Also gauze is easily replaced when soiled.

Cabinets.—Special cabinets in which the temperature and humidity may be varied permit control of oviposition, which may be desirable as will be brought out later. However, in laboratories or rooms where the temperature does not fall below 18° C. nor rise above 32° C. cabinets are not essential and our results under these conditions have been quite satisfactory. If plenty of fresh drinking water is supplied at all times the relative humidity of the air is not important as long as it does not fall below 35 per cent nor rise above 85 per cent.

Foods.—Murdoch and Smart (1931) and Elgin (Baer, 1930–1931) have discussed their methods and suitable foods in recent publications, and we have also experimented considerably in this field. After testing a variety of natural foods and a number of synthetic ones we have reached the conclusion that, if plenty of drinking water is supplied by inverting a small beaker upon a circle of filter paper in a petri dish, the only other food requirements may be adequately met with dry granulated sugar and fresh lean meat. This makes a decidedly simple diet which can be readily handled and has given very satisfactory results over a period during which a large number of consecutive generations have been reared. Elimination of liquid foods and syrups lessens the mortality from drowning and from poisons due to fermentation. The dry sugar can be

eaten readily by the flies and is kept in the cages at all times except when the flies are ovipositing. Meat should be fed at least once in each two days. It may be fed each day if the eggs laid can be used as frequently as that.

In a series of experiments on foods for larvæ, conducted under conditions of controlled temperature and humidity, the following foods were used: (1) lean beef, (2) lean beef and beef fat, (3) lean beef and trypsin, (4) lean pork, (5) beef liver, (6) fish, (7) boiled egg, (8) dried blood and casein mixed with water. Numbers 1, 2 and 4 gave the most rapid rate of development and seemed best in all other respects although 6 and 8 were utilized almost as readily by the larvæ. The life cycle was completed on all of the foods and there was no noticeable effect on the sex ratio.

Not infrequently larvæ leave their food supply before they have fully developed. Wardle (1930) states that relative humidity of the atmosphere is of considerable importance as a causative factor and that if it falls below 60 per cent the larvæ will leave the meat. We have not found this to be true if the meat does not become too dry. However, there are two factors which do play an important part in producing this reaction: overcrowding of the food supply, and, probably of primary importance, the accumulation of gases in the container used for rearing. Experiments run with a ventilator system for some of the containers and without for others demonstrated this fact.

Pupation Jars.—When larvæ are full grown they leave the food. If just prior to this the culture vessel in which they are feeding is placed in a larger container with strips of crumpled paper toweling, the migrating larvæ will crawl through the paper thus drying and cleaning themselves. They may be left here to pupate, or better, they may be removed and scattered through cheese cloth in another container. The larvæ will work their way into the folds of the cloth and there come to rest. This prevents their collecting in large writhing masses thus disturbing each other continually and probably delaying pupation. The cloth is also decidedly easier to handle than soil or sand, the natural repositories for pupæ. When pupation is complete the cloth is spread out and the pupæ removed and placed in petri dishes until emergence starts, after which they are transferred to the cages.

Segregation of the pupæ and the sex ratio.—Some workers have attached considerable importance to the matter of sex ratio in the culture cages. This is not of sufficient importance to justify the amount of labor required to count out the sexes for each cage. If a large stock of prepupæ are obtained and the first pupæ that form removed, they will, upon emergence, be found to have yielded more males than females. Likewise, the last ones to pupate will yield more females than males. If, however, all are permitted to pupate before being counted out into whatever numbers are desired for cage lots, the lots upon emergence will be found to show a sex ratio of approximately one to one. A preponderance of males is not undesirable as careful counts have shown that the males die in larger numbers during the first two weeks of a cage history.

Temperature and Oviposition.—The entire procedure of fly rearing centers around oviposition since upon this depends the supply of larvæ for the clinic. For this reason, we have paid more critical attention to this than to any other one problem. It has been studied for more than a year and over many generations. For this work we have used mostly *Phormia regina.* While light and humidity exert a minor influence, the controlling factor is unquestionably temperature. These flies have an oviposition range of from 20° C. to about 34° C. with an optimum near 26° C. At the lower temperatures, the longevity of the flies is greatly increased but the number of *eggs per female per day* is greatly decreased. At the higher temperatures, the number of *eggs per female per day* is increased but the total number of *egg-laying days* is decreased because the flies do not live so long. These two factors tend to equalize each other at the extremes but a temperature near 26° C. gives the *greatest total deposition of eggs per female.*

The practical application of these studies is self evident. If the clinical material makes it necessary to speed up the production of eggs it can be accomplished within two days by increasing the temperature in the cages to approximately 30° C. and supplying plenty of food and drinking water. However, it must be remembered that the flies will not live so long at this higher temperature and will have to be replaced at an earlier date. Consequently, the total number of eggs from any one cage will be reduced. This type of behavior in oviposition conforms to that worked out for a number of other insects that have been studied.

STORAGE.

Another problem of practical importance is the possibility of maintaining reserve stocks for quickly increasing the number of adults producing eggs, or for safeguarding against any sudden mortality thus endangering the supply of sterile larvæ for the clinic. Cold storage has been resorted to for this purpose.

The mortality of eggs in storage is too great after seventy-two hours to be of much practical application. Larvæ of various ages show the following results. Newly hatched larvæ cannot be held, to advantage, much more than one week. Larvæ, which have fed for twenty-four to thirty-six hours, will continue to feed, if returned to the food, after two or three weeks in storage. Some have been held for four weeks in refrigeration but the mortality is high. Larvæ that were full grown and ready to migrate from the food were held four weeks after which they pupated and emerged 88 per cent. The temperature used was 8° C. to 10° C. Longer periods of storage ranging from six weeks to six months, over a wide range of temperatures, gave results with a mortality so high that they were of no value. These observations offer obvious possibilities.

The storage of pupæ and adults has been tried with some success. They can both be held for one, two, or three weeks. However, at present, the storage of larvæ seems to offer the greatest possibilities.

PRODUCTION OF STERILE LARVÆ FOR THE CLINIC.

From the point of view of the laboratory, the chief objective is the production of sterile larvæ for the clinic. This part of the work is of such great importance that the utmost precaution must be followed in its pursuit. The eggs are collected from slices of fresh beef that have been placed on circles of filter paper in petri dishes. The dishes and paper have been previously autoclaved to reduce the possibility of contamination. Such preliminary precautions have shown that they contribute materially to success in the sterilization of the eggs. With flamed forceps the eggs are removed from the meat, placed in sterile vials and labeled. Within twenty-four hours they are subjected to a sterilization procedure which does not materially affect the hatching but which does eliminate the ordinary bacterial contaminants when the precautions already outlined are scrupulously adhered to. The technic employed at present

for planting the eggs is essentially that worked out in co-operation with Dr. G. F. White of the United States Bureau of Entomology at Washington, D. C. It consists of dissolving the egg masses apart by shaking not too vigorously in a vial of sterile saline with glass beads. The saline is then pipetted off and replaced by a solution of bichloride of mercury (1:2000) in 25 per cent ethyl alcohol in which the eggs are bathed for not less than fifteen minutes nor more than twenty minutes. They are then poured through a previously sterilized unit consisting of a Gooch crucible containing a small circle of cheese cloth which strains out the eggs. After washing thoroughly with sterile saline to remove any excess of the sterilizing solution the cloth containing the eggs is removed with sterile forceps and placed in a sterile tube of autoclaved agar containing a small amount of meat, much as any bacterial culture might be made. Some of the eggs and the tubes of young larvæ are tested for at least three days for aerobic and anaerobic bacteria before they are released to the hospital for use in clinical cases.

The possibility of retarding or suspending the metabolic processes in the larval stage has been mentioned above as a solution to the problem of maintaining a sufficient reserve of potential flies. This temperature control of larval development has been utilized also in the establishment and maintenance of reserves of larvæ for clinical use. Newly hatched larvæ are too small or too young as a rule to survive immediate implantation in a wound. Therefore, a certain minimum size for wound implantation which is attained in from twenty-four to thirty-six hours at 37° C. or in 72 hours at room temperature (24° C.) is desirable. When the optimum size of the larvæ has been reached, it is possible to suspend growth and development temporarily by reducing the temperature to 8° to 10° C. If the larvæ introduced into a wound are within the seventy-two hour (24° C.) growth size (even though kept for from fourteen to eighteen days at this stage by low temperature) a period of from four to five days of scavanger activity may be anticipated before pupation occurs and a new implantation is required.

CLINICAL RESULTS.

It must be emphasized that the use of fly larvæ in osteomyelitis in no sense eliminates the surgical aspects of the treatment, but is advanced as a method of after treatment

superior to those formerly advocated. The success of any form of treatment in the disease is conditioned very largely by two factors: (1) the age of the patient, and (2) the duration of the disease. Acute or chronic osteomyelitis seems to heal more readily in the very young patients, and the most resistant and difficult cases to treat satisfactorily are those of many years standing in elderly patients. Thus, the importance of an effective treatment early, that the changes which come subsequent to repeated relapses and operations may not jeopardize the possibility or permanent cure.

To Baer's 89 reported cases may be added 17 which have had more or less intensive maggot treatment following operation in the osteomyelitis clinic of the Ohio State University during recent months. In 12 of these cases healing occurred promptly in from four to nine weeks. The remaining 5 represent the first cases in our series and did not have the full benefit of the treatment because of certain limitations then existing in technic and experience. It must be pointed out that success depends in great measure on a certain acquired experience both in the establishment of an efficient laboratory routine and in the effective handling of the treatment in the patient by the surgeon. More complete data on the cases treated in this study are being presented in another communication (Wilson, Doan and Miller, 1932), together with the technic of applying and "caging" the larvæ within the infected areas of bone and tissue destruction.

The mechanism by which larval infestation assists nature in the elimination of infection and the promotion of healing is, of course, one of the chief objectives of this joint study. Through the interest and cooperation of Professor Wm. A. Starin, of the Department of Bacteriology, it has been determined from cultures of larvæ, taken from our stocks for clinical use, that no bacteriophage principal has been present, which, if introduced into the lesions inadvertently with the maggots, might have exerted a lytic effect upon the staphylococci, which have been found almost uniformly to be the causative agent in this series of cases. We have observed a marked change in the hydrogen ion concentration of the wound from an acid to an alkaline reaction following maggot implantation. Does this inhibit pathogenic bacteria? Do the enzymes or excretions of the larvæ exert any direct effect upon the healing process? Or, is it a vital phenomenon wholly related to the

scavenger propensities of this organism for dead tissue? The more or less empiric observations of clinical healing will not suffice indefinitely. An answer to these various questions must be sought for as their satisfactory understanding is essential to the scientific approach to that larger problem of wound healing and tissue repair, toward which the future work of this group is being directed and to which we feel the use of fly maggots in osteomyelitis may contribute.

The osteomyelitis clinic, which is under the direction of the College of Medicine at both the University and Children's Hospitals, is to be continued through the coming year and is available to the sufferers from this malady from anywhere in the state or surrounding community.

LITERATURE CITED.

1. **Baer, Wm. S.** 1930. The Treatment and Cure of the Disease known as Osteomyelitis (Hearing before Congressional Committee on World War Veterans' Legislation), U. S. Govt. Printing Office, Washington.

2. **Baer, Wm. S.** 1931. The Treatment of Chronic Osteomyelitis with Maggots (Larva of the Blowfly). *Jour. of Bone and Joint Surgery, XIII*, No. 3, p. 438.

3. **Murdock, F. F.** and **Smart, T. L.** 1931. A Method of Producing Sterile Blowfly Larvae for Surgical Use. *U. S. Naval Med. Bull. 29*, No. 3.

4. **Wardle, Robert A.** 1930. Some Significant Variables in the Blowfly Environment. *Ann. of Applied Biology, XVII*, No. 3.

5. **Wilson, E. H., Doan, C. A.,** and **Miller, D. F.** 1932. The Baer Maggot Treatment of Osteomyelitis. *Ohio State Medical Journal.* In Preparation.

THE ANT, POGONOMYRMEX OCCIDENTALIS, CR., ASSOCIATED WITH PLANT COMMUNITIES.

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INTRODUCTION.

In view of the fact that *Pogonomyrmex occidentalis* exhibits a wide range of distribution in the western United States it seems advisable, in this paper, to relate it to two contrasting areas, one, Tooele Valley, Utah, the other, Craters of the Moon National Monument, Idaho. Each area represents a series of distinct vegetational zones.

TOOELE VALLEY, UTAH.

Tooele Valley, Utah is bounded by the Stansbury Mountain Range on the west, the Oquirrh Mountains on the east, on the south by a spur of the Stansbury Range and on the north by the southern shore of Great Salt Lake. The area of the valley floor roughly totals 250 square miles.

A wide range is shown in the salinity, or the "alkali" content of the soils of the Tooele Valley. The soils of the foothills are characterized by a low salt content while those of the flats adjacent to the lake are highly saline. These salts comprise sodium chlorid and smaller quantities of the soluble salts of potassium, magnesium and calcium.[1]

The vegetation of the valley is markedly distributed into vegetational zones (Fig. 1) and the survey of the author, relating to the distribution of *P. occidentalis*, was entirely conducted in these various zones, beginning at the shore of the lake and extending to the foothills of the mountains.

The ant in question constructs dome-shaped mounds with surrounding circular areas cleared of vegetation, on level or gently-sloping ground.[2] These mounds are composed of small pebbles or other material and generally vary in composition

[1]Data of Kearney, T. H., et al.. from "Indicator Significance of Vegetation in Tooele Valley, Utah." *Jour. Agr. Res.*, Vol. 1, No. 5: 370–372. 1914.

[2]Cole, A. C. "The relation of Pogonomyrmex occidentalis to its habitat." (To be published in Ohio Jour. Sci)

with the surrounding strata. The ants obtain their food by carrying seeds from nearby plants and storing them in more or less specialized chambers within the mounds.

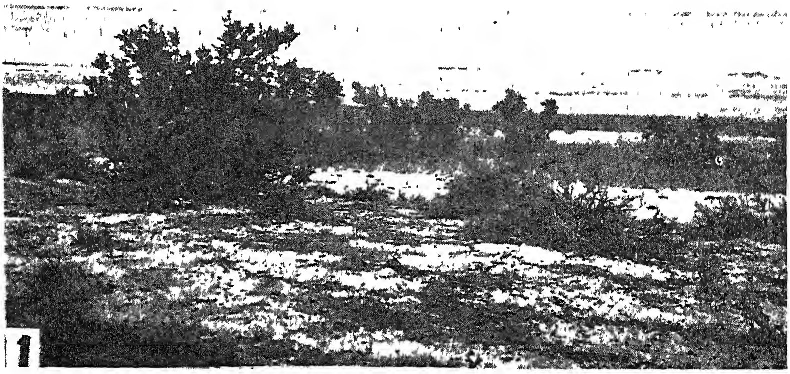
The Salt Flats.

These flats (Fig. 2) border the lake and are composed of a sandy stratum containing about two percent sodium chlorid. The flats adjoining the lake support no vegetation but as one proceeds toward the mountains distinct plant communities are observed on the salt flats, supporting *Allenrolfea occidentalis*, *Salicornia utahensis* and *Salicornia rubra* as dominant species. In these communities few and scattered mounds of *P. occidentalis* were observed. The mounds were, as a rule, small and distinctly cone-shaped and were situated in open spaces between plants. (Fig. 3).

Such a location is very different from normal upland habitats of the ant in soils of considerably less salinity. The brood is apparently well able to mature under extremely saline conditions. The stored seeds of greasewood and shadscale, carried from nearby areas, were grouped in chambers very near the surfaces of the mounds. By keeping the seeds dry in this manner germination was retarded to a marked degree. The brood chambers, however, were well under the surfaces of the mounds, sometimes at a depth of two feet, where the brood was all but bathed in the salt water from the lake. Such an unusual habitat serves to exemplify the plasticity of the mound-building instincts of the ant.

The Grass-Flat Communities.

In these communities, where *Distichlis spicata*, *Sporobolus airoides* and *Chrysothamnus graveolens glabrata* dominate (Fig. 4), *P. occidentalis* mounds are few and widely scattered. At no time did I observe two mounds closely adjacent to one another. The mounds were always large, distinctly cone-shaped and with somewhat regularly-circular denuded areas usually cleared of all vegetation. In spite of the abundance of nearby seeds of *S. airoides* and *D. spicata* the ants were more inclined to harvest seeds of shadscale, greasewood and Russian thistle. These were found in chambers, often with the brood, at a depth of three to fourteen inches from the apexes of the mounds.



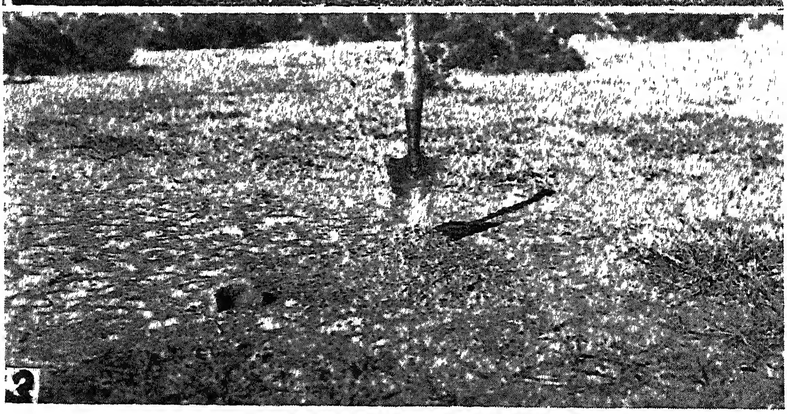
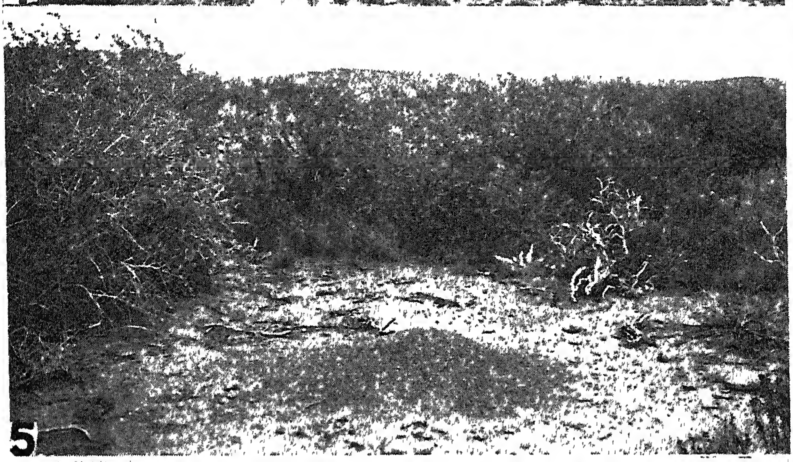


FIG. 1. Salt flats of Great Salt Lake, illustrating the zonal arrangement of vegetation. In the background is the Allenrolfea community and in the foreground clumps of greasewood. (Original).

FIG. 2. Salt flats of the Tooele Valley with wide expanses of bare areas in the background. The vegetation in the foreground is salt grass (*Distichlis spicata*) and in the background *Allenrolfea occidentalis*. (Original).

FIG. 3. Mound of *Pogonomyrmex occidentalis* in a community of *Allenrolfea occidentalis*. Tooele Valley, Utah. (Original).



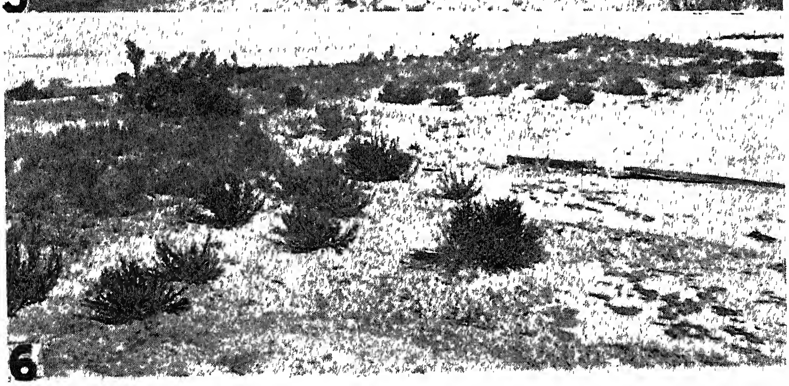


FIG. 4. The grass-flat community of Tooele Valley. Note the scattered plants of rabbitbrush (*Chrysothamnus graveolens glabrata*) associated with tussock grass (*Sporobolus airoides*). (Original).

FIG. 5. Mound of *Pogonomyrmex occidentalis* in the Greasewood-Shadscale Association. Note the large cleared area surrounding the mound. (Original).

FIG. 6. A mixture of vegetation extending out on the salt flats. The darker plants are those of greasewood (*Sarcobatus vermiculatus*). (Original).

The Greasewood-Shadscale Association.[3]

This association is so termed from its dominant members, *Sarcobatus vermiculatus* and *Atriplex confertifolia.* It forms a wide belt across the valley between the grass flats and the schadscale association. Enough soil moisture is available for the survival and growth of greasewood and yet the upper two feet of surface soil are dry enough to support shadscale.

Mounds of *P. occidentalis* are comparatively abundant in this association (Fig. 5) averaging two feet in height and containing large numbers of workers and brood. As the vegetation of this association approaches the salt-flats the schadscale gradually disappears due to the increase in moisture content of the soil. Likewise, as the soil moisture becomes greater *occidentalis* mounds become fewer and, at the juncture described above, the average number of mounds correlates with that of the salt flat communities.

Seeds harvested by the ants consist chiefly of those of schadscale and greasewood together with those of *Bromus tectorum*, an annual typical of this association. They are lodged in chambers, with or without brood, in a position in about the centers of the mounds. The brood chambers are usually found at this level also but may extend below the ground level.

The Schadscale Association.

Dominating is *Atriplex confertifolia* in a minor society of other vegetation including *Poa sandbergii, Kochia vestita, Opuntia sp., Artemisia spinescens* and *Lepidium jonesii. Occidentalis* mounds are only slightly more numerous than in the mixed greasewood-shadscale association and are most commonly found in somewhat open, grassy areas. Seeds harvested by the ants include those of *Poa sandbergii* together with those of greasewood and shadscale. The brood chambers, as well as the seed chambers, are situated near the bases of the mounds or often well under the ground level. The mounds are composed of pebbles and are often covered with a layer of chaff from harvested seeds.

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[3]The term "association" in this paper is used as defined by Kearney, T. H., et al. (*Jour. Agr. Res.*, Vol. 1, No. 5: 374, (1914), as "an assemblage of plants occupying a relatively uniform environment, having an easily recognizable appearance or 'physiognomy' and characterized by the predominance of one or a few species."

Large patches of short Russian thistle are succeeding some of the natural vegetation and in these "islands" many mounds of *P. occidentalis* are aggregated. Under these conditions the Russian thistle provides a great quantity of seeds which are harvested by the ants.

The shadscale of this association often extends out on the salt flats and usually terminates in a wild mixture of vegetation (Fig. 6). Many of these ridges also extend into the lake. In these places mounds of *occidentalis* follow the trend of the dominant and appear abundantly on the ridges.

The Kochia Association.

The Kochia association lies as a narrow, continuous belt extending across the valley between the shadscale area and the lower boundary of the typical sagebrush association. The plants are rather widely separated resulting in a large number of intervening bare areas from which most of the former grasses have been removed by pasturing. In such open areas mounds of *occidentalis* are occasionally to be found, their numbers, however, being far less than those of the preceding communities except perhaps the salt flats. Mounds of *occidentalis*, when they occur, are small, irregular and wind-blown, composed of earth instead of pebbles and consisting of only a comparatively few occupants. The brood chambers are proportionately small and irregularly situated throughout the mounds. The seed chambers are larger than the brood chambers and are often stocked with an abundance of shadscale, greasewood and Russian thistle seeds.

The Sand-Hill Mixed Association.

The sand-hill mixed association[4] is in the southern part of the valley. There a wide variety of vegetation, of which *Juniperus utahensis* and *Artemisia tridentata* are representative, grows on sand dunes or sandy ridges formed by the continuous sweep of the southwest winds. The stratum is almost pure sand some of which is in continuous motion. In such regions we should not expect to find *P. occidentalis* mounds in any great numbers. Only one mound was located and that partially protected from the wind by surrounding plants of sagebrush. This mound was in an incipient state and it is doubtful whether it would have ever become a more or less stable unit.

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[4]Terminology of Kearney, et. al., ibid.

The Sagebrush Association.

The sagebrush association is one of the most important vegetational units of Tooele Valley. It is found on the gently-sloping foothills and bench lands of the mountains, the alluvial fans and the sand hills. The dominant of this association is *Artemisia tridentata* which is associated with a number of other perennials as well as numerous annuals and biennials, among the most important being *Bromus tectorum* and *Erodium cicutarium.*

In this association *occidentalis* mounds reach their quantitative peak. In no other community do we find as many mounds so closely aggregated with one another and continually increasing in quantity. In fact, it is safe to estimate that there are approximately as many incipient colonies of the ant as there are fully developed mounds. The mature mounds are large, averaging two feet in height, and are surrounded by large cleared areas.

In pepper-grass (*Lepidium sp.*) "openings," scattered throughout the sagebrush association, the mounds were more closely aggregated than in any of the other areas of the association. In fact it is barely possible that the Lepidium in this locality started from the germination of seeds harvested by *occidentalis* workers from outlying areas, for, in many cases, the mounds as well as the denuded areas supported scattered individuals of the plant. Mounds of *occidentalis* opened in this area were found to contain large quantities of Lepidium seeds, often surpassing the number of Bromus seeds, though *Bromus tectorum* was extremely abundant throughout this association.

The Sagebrush-Juniper Community.

The sagebrush-juniper community is a variation of the typical sagebrush association and is located on the lower mountain slopes. It also extends into the upper portion of Tooele Valley. In this community there is a marked deficiency in the number of mounds of *P. occidentalis* in spite of the more pebbly soil, common to areas of *occidentalis* abundance. Scattered mounds were found in the more open areas between the junipers. These contained large quantities of *Bromus tectorum* seed, commonly present in the community.

Craters of the Moon National Monument, Idaho.

The Area in General.

Craters of the Moon National Monument lies 26 miles southwest of Arco, Idaho. The soil of the region is largely composed of cinders formed of basalt lava from both aa and pahoehoe lava flows.[1] The pahoehoe type covers about half of the area of the Monument. It affords a smooth, billowy appearance very distinct from the rough, jagged aa flow which occupies the remainder of the area. Many hills of cinders which originated from adjacent cinder cones dominate the landscape. On these hills most of the vegetation is found.

If Irving[2] refers, as Stearnes[3] believes, to the Monument as "an area of about 60 miles in diameter, where nothing meets the eye but a desolate and awful waste, where no grass grows, nor water runs, and where nothing is to be seen but lava," he made far from accurate observations of the area. The vegetation is surprisingly abundant and is separated into various and distinct plant communities. These communities are arranged as various zones in the Monument, their positions apparently determined by soil texture, moisture and hydrogen-ion concentration.

The Semi-desert Communities.

1. The Sagebrush Community:

The sagebrush community is one of the most prominent vegetational units of the region. It occupies, in pure stands, many areas within the Monument but as a rule it is found on the cinder buttes. In association with the dominant sagebrush are *Agropyron repens*, *Agropyron smithii*, *Purshiana tridentata* (buck bush), *Chrysothamnus graveolens* (rabbit brush) and *Bromus tectorum* (brome grass).

In the sagebrush community mounds of *Pogonomyrmex occidentalis* are found in greater abundance than at any other point in the limits of the Monument. The majority of them are of average size, about two feet in height and three and

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[1]Stearns, H. T., *A Guide to the Craters of the Moon National Monument, Idaho.* Bull. Idaho Bur. Mines & Geology, XIII (1928), 7–59.

[2]Irving, Washington, *The Adventures of Captain Bonneville.* U. S. A., Hudson ed., New York, 1868, 203.

[3]Stearns, op. cit., p. 7.

one-half feet in diameter, and are surrounded by large areas from which the vegetation has been cleared by the ants. Most of the mounds are composed of cinders which offer fair insulation of the brood in chambers at the bases of the structures.

2. The Sub-alpine Meadows:

On the tops and upper slopes of the higher hills are quite dense meadows of the following vegetation:[4]

GRASSES

Ericoma hymenoides (Indian millet).
Oryzopsis bloomeri (wild rice).
Sitanion cinereum.
Stipa occidentalis.
Melica bella (rye grass).
Sitanion rigidum.
Stipa comata (spear grass).

SHRUBS AND HERBS.

Agoseris sp. (goat chicory).
Castelleja pinetorum (paint brush).
Crypthantha torreyana (borage).
Eriognum depressum.
Eriognum subalpinum.
Eupatorium occidentale (boneset).
Crepis acuminata.
Gayophytum ramosissimum.
Lewisia redeviva (bitter root).
Lygodesmia spinosa (prairie pink).
Opuntia xanthostemma (cactus).
Pentstemon deustus.
Potentilla biennis (cinquefoil).
Salsola pestifer (Russian thistle).
Amelanchier alnifolia (service berry).
Circium orthe (Canadian thistle).
Eriognum aridum.
Eriognum ovalifolium.
Eriognum vimineum.
Galium boreale (bedstraw).
Coleosanthus grandiflorus.
Heuchera ovalifolis (alum root).
Lupinus tenulus (lupine).
Opuntia polycantha (cactus).
Oreocarya dolosa (borage).
Philoria tenufolia (desert pink).
Potentilla dichrona.
Ribes cereum (currant).

In spite of the abundance and the wide variety of vegetation *occidentalis* mounds are very scarce, only an occasional colony being found. In mounds which were opened the seed chambers were in about the centers of the mounds and were stocked with seeds of many of the plants listed above.

The Laval Plant Communities.[5]

1. The Cinder Meadows:

The cinder meadows[6] are usually located on the slopes of the cinder buttes and rarely on the sides of the spatter-cones.[7] The representative vegetation is not abundant but *Lewisia redeviva*, *Mimulus nanus*, *Eriognum depressum*, *Eriognum aridum*, and *Eriognum ovalifolium* are outstanding plants.

[4]Ibid.

[5]Terminology of the author.

[6]Ibid.

[7]Stearns, op. cit., p. 23.

The few and scattered mounds of *P. occidentalis* in the cinder meadow community are small and irregularly constructed, with few workers and little brood. The seeds stored in the somewhat specialized seed chambers represent those of *Salsola pestifer*, *Stipa comata*, and *Stipa occidentalis* and not those of plants dominating the meadows. From the appearance of the mounds and the environmental conditions under which they survive the somewhat recent invasion of the ant is evident.

2. The Pine Community:

The pine community is probably the least important and most poorly represented community of the Mounment. The dominant, *Pinus flexilus*, (limber pine), never exists in pure stands at the Craters of the Moon. Unfavorable environmental factors have dwarfed and twisted the trees and have limited their numbers and spread. The limber pine is better adapted to growing on the cinders than on the lava[8] and it is there that it is found in its greatest numbers. Associated with *Pinus flexilus* are *Prunus melanocarpa* (choke cherry), and *Amelanchier alnifolia* (service berry) as well as *Artemisia tridentata* (sagebrush) and *Chrysothamnus graveolens* (rabbit brush).

Pogonomyrmex occidentalis is represented in the community by a few mounds usually scattered in the interspaces of the sagebrush plants but occasionally at the bases of the pines. The mounds are small, irregular in outline and composed of coarse cinders. The brood chambers are small, few in number and dispersed throughout the mounds. The chief seeds harvested by the ants are those of *Amelanchier alnifolia* and *Salsola pestifer*.

The Alpine Groves.

Small stands of quaking aspen, *Populus tremuloides*, grow on the slopes of Big Cinder and Fissure Buttes, two prominent cinder cones of the region, where the snow lies late in the spring. Only a few plants are associated with *Populus tremuloides* in the community, among the more outstanding being *Stipa comata* and *Agropyron spp.*

Of the limited number of mounds of *P. occidentalis* present in the community all are in the large bare areas between the vegetation. They are generally small and somewhat incon-

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[8]Ibid., p. 50.

spicuous, without definite cone-shaped outlines and with only slight denuded areas. The brood chambers and the seed chambers are few in number and are irregularly located throughout the mounds, many of them even below the ground level.

LITERATURE CITED.

Cole, A. C., Jr. "The relation of Pogonomyrmex occidentalis to its habitat." (To be published in Ohio Jour. Sci.)

Kearney, T. H., Briggs, L. J., et al. "Indicator significance of vegetation of Tooele Valley, Utah." *Jour. Agr. Res.*, I, (1914), 365–417.

McCook, H. C. *The Honey Ants of the Garden of the Gods, and the Occident Ants of the American Plains.* J. B. Lippincott & Co., Philadelphia, 1882.

Stearns, H. T. *A Guide to the Craters of the Moon National Monument, Idaho.* Bull. Idaho Bur. Mines & Geology, XIII (1928), 7–59.

Weaver, J. E. and **Clements, F. E.** *Plant Ecology.* McGraw-Hill, New York, 1929. (Reference on p. 411.)

Wheeler, W. M. *Ants; Their Structure, Development and Behavior.* Columbia Univ. Press, New York, 1926.

Wildermuth, V. L. and **Davis, E. G.** *The Red Harvester Ant and How to Subdue It.* U. S. D. A., Far. Bull. 1668. 1931.

FOOD OF THE MUSKRAT IN SUMMER.

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Few attempts have been made to study the food supply of the muskrat under natural conditions in the northern states. Almost every paper on the animal lists some foods, but most dismiss this subject with the statement that they eat cat-tails and other marsh vegetation. By far the best list of foods published (Johnson, 1925) names several foods of animal origin and some twenty-six plants. In addition to this descriptions of what portion of the plants is consumed and, in some cases, how it is eaten, are given. Arthur, (1928, p. 338), lists the foods usually eaten in Louisiana, as does Svihla (1931).

The work upon which the following report is based was carried on from June 8 to September 14, 1930, while the writer was employed as temporary Mammalogist, Division of Conservation of Ohio. The work was part of a survey of the muskrat in the state, and was carried on under the direction of E. L. Wickliff, Chief, Bureau of Scientific Research. The indebtedness to Mr. Wickliff for the opportunity to do the work, and for his suggestions and co-operation is gratefully acknowledged by the writer. Professor L. H. Tiffany is responsible for many of the identifications. Without his help the list of food plants would be shorter and would lose much of its value. Any mistakes are the writer's, who willingly admits that his knowledge of botany leaves much to be desired.

The habitats of the muskrat in Ohio may be divided roughly into two types: marsh or swamp habitats and stream habitats. There is no accurate method available which would permit an estimate of the relative number of animals in each habitat, but it is the opinion of the writer that the numbers in Ohio are approximately equal. The concentration in marshes is more noticeable, but the larger area of stream banks, as compared with marshes equalizes the numbers.

In the marshes, which are located chiefly along the western shore of Lake Erie, but occur locally over much of the northern half of the state, the study of food plants is complicated by the

house building activities of the muskrat. It is often a problem to determine just what has been cut for food, and after eating, how much was used in the construction of houses, and what was gathered for such building. As the activity of house building is seasonal, the problem is somewhat simplified. Plants are listed as food only where the animals were observed feeding upon them, or where the plant has been cut and portions eaten before being utilized for raft or house building.

Where dikes, ditch sides, or roadways pass through a marsh the muskrats feed on some of the plants found in such places, in addition to the marsh plants which furnish the bulk of the food. The plants eaten here offer a transition from the marsh plants to those eaten by the stream or "bank rats."

As would be expected, the largest variety of foods is eaten by these "bank rats," for they range well back from their burrows in search of desirable foods. When food plants are found they may be cut and dragged entire to the water, they may be cut up into convenient size for transportation, or they may be consumed on the spot. Sometimes one finds all three conditions on the same plot. Since these animals live in burrows and do not usually use plants except for food and bedding material, the problem is simpler than in the marsh; but care must be exercised in determining just which plants were used for food. In most burrows the usual bedding was grass or sedge. In the houses cat-tail appeared to be used to the exclusion of other materials.

During the course of the survey attempts were made to visit certain places at frequent intervals to study the seasonal variation in foods. The habit of the muskrat is to take most of its food to some protected place for consumption. These feeding stations are usually located in a burrow mouth, under projecting roots, or under a snag or tree at the edge of the water. In seasons of low water these piles accumulate until they may amount to two or three bushels, for only a small portion of each plant may be eaten. High waters remove these piles, so it is relatively easy to determine the length of time that has elapsed since the pile was started. Thus a good idea of the seasonal variation may be formed from a study of these accumulations.

With the "marsh rats" the formation of rafts by the accumulation of debris from feeding offers some information as to seasonal habits; but since the raft is usually in still water, the accumulation is not so easily dated. The writer proposes to

destroy some rafts in an attempt to study seasonal feeding habits in such areas.

Little or no work on the winter foods has been done. It is to be hoped that this work will be carried on, for the critical period, so far as food supply is concerned, is in winter and early spring.

One interesting sidelight brought out is the fondness of the muskrat for certain plants not native to America, but invaders from Europe and Asia. The muskrat, except for a few that have been introduced into Europe, is confined to North America. A recent study in Saxony (Ulbrich, 1927) lists *Acorus*, *Elodea*, *Potomogeton*, *Alisma*, and species of *Gramineae*, *Cyperaceae*, *Juncaceae*, *Nymphaeaceae*. Representatives of these groups of plants are eaten in Ohio. At least one, *Elodea*, may have been an American species introduced into Europe. This brings to mind the fondness of a native American cat, the mountain lion, for catnip (*Nepeta Cataria*) which was introduced from Europe where the mountain lion does not occur. How long were the plant and mammal lines separated before they were reunited? The same question might be asked in connection with the muskrat.

The foods listed here are by no means exhaustive, and are offered only as a beginning.

ANNOTATED LIST OF FOOD PLANTS.

Common cat-tail (*Typha latifolia*).
Narrow-leaf cat-tail (*Typha angustifolia*).

The common cat-tail is the outstanding food of the marshes. It is not, however, the sole food anywhere, as the writer will show. Because of its conspicuousness in growing, the amount cut, and its use both as bedding and building material in houses, the common impression has grown up that it furnishes everything that the muskrat needs. It forms the back bone of the diet, but may be neglected for many other plants, such as the cow lily, Jerusalem artichoke, duckweed, and others.

In eating the cat-tail the rats reach up as far as possible, standing on the hind legs, cut the leaf, and then cut or tear it into pieces several inches in length. After a few nibbles the piece is discarded and another taken up. The food is not washed; the sound of the tearing is audible at a distance of twenty feet. In addition to the leaf the base is eaten as well as the tender shoots from the roots. The roots themselves are not often attacked during this season.

The narrow-leaf cat-tail is not nearly so abundant as the common cat-tail, but is treated in the same way. When drought comes the common cat-tail is better able to resist wilting.

Bur-reed (*Sparganium eurycarpum*).

The base of the stems of this plant are eaten extensively. The cutting is done at the base, after which a small portion is consumed. On several occasions the prickly seed heads had been gnawed, but had not been eaten.

Pondweed (*Potamogeton foliosus*).

A few stems of this plant showed signs of gnawing. While it is used as house building material, it is of great importance neither in this connection nor as food.

Broad-leaved Arrow-head (*Sagittaria latifolia*).

During the early summer the base of the stalk is eaten. Unlike the condition found in New York (Johnson, 1925, p. 249) this plant furnishes considerable food to the muskrats along Lake Erie and in the "bottoms" along Killbuck Creek, to mention but two outstanding habitats. Later on the fruiting heads also were eaten.

Grasses: (*Panicum species*), (*Calamagrostis canadensis*), (*Poa compressa*), (*Poa pratensis*), (*Hordeum jubatum*).

The grasses are treated together as it was impossible for the writer to distinguish between them in the field. The fragmentary condition of many specimens increased the difficulty, so only those species are listed that have been identified by Doctor Tiffany from specimens submitted to him. Undoubtedly many more species are eaten when other food is too tough or too difficult to secure.

Generally only the tender basal stem is eaten as in the sedges and many other plants, but occasional patches of grass are found which show the effects of cropping. Here the grass is kept short by the animals' eating off the top growth without, apparently, any of the material being carried away. Woodchucks, too, attack grass after this fashion. The only other plant so eaten is white clover (*Trifolium repens*) and sweet clover.

On the banks of one pond grass stems had been piled over the entrance to a burrow which had been uncovered by the lowering of the water. These stems formed a half-house, as it were, the bank forming the back half as though a muskrat house had been cut in two and one half placed against the bank. The pond was enclosed in a rat-proof fence and only grass and *Lemna* were available, which probably explains the use of grass stems in construction. The pile contained two bushels or more, all well packed. The restricted diet did not effect the animals adversely, for many were seen, all of which were in good condition.

Under certain conditions grasses may form an important item in the diet of muskrats, and they appear to thrive on it. Of the grasses cut *C. canadensis* is most frequently encountered.

Sedge (*Cyperus strigosus*), (*Scirpus fluviatilis*), (*Scirpus validus*), (*Scirpus species*), (*Carex lupulina*), (*Carex vulpinoidea*).

These families are grouped together, as they were not identified in the field and because they furnished the same type of food. Many

species not listed are consumed, too. As a rule only the tender basal portion of the stem is eaten, although a few fruiting heads were found which showed that the muskrats had sampled them.

Duckweed (*Lemna*).

Muskrats were observed feeding on what appeared to be duckweed. In each case the animal swam about slowly, eating the floating plants with evident relish. The sound was audible at a distance of fifty feet and was very noticeable when the animals were closer. *Lemna* was found also on the tops of houses and at feeding stations. It may have been carried there as building material rather than as food, as it showed the characteristic balled condition of material used in house construction. The abundance of duckweed in certain habitats, notably about the shores of still lakes and ponds, makes it an item of considerable importance, for in most cases where animals were observed eating it, it was chosen in preference to *Typha*.

(*Wolffia*).

What has been said of *Lemna* applies possibly to *Wolffia*. (Johnson, 1925, pp. 248.)

Willow (*Salix spp.*).

Both leaves and bark of the willow are eaten, young shoots, recently cut, being found from time to time. One captive muskrat always ate willow in preference to *Typha*. The abundance of young willows along streams running through pastures does much to encourage the establishment of burrows in this type of habitat.

Elm (*Ulmus sp.*).

The leaves and bark of young shoots of the elm are a favorite food of the muskrat whenever they are available. Sprouts are cut about twelve to sixteen inches above the ground and transported to the water where the leaves and some of the bark are eaten. Cutting apparently takes place as soon as the sprouts leaf out. Elm was eaten in one habitat which was unusually rich in the variety of foods available and where there was no need for eating anything unpalatable. Such efforts were made to secure the elm that the writer is convinced of its desirability as a food for muskrats.

Curly Dock (*Rumex crispus*).

The internodes of curly dock forms an important item of food. In addition to the internodes the leaf base is also eaten at times. Along the Mohican River and most similar streams examined this dock was extensively eaten. Cutting begins early, as the plants are eaten usually before they flower. Later, when the seed has set, the plant appears again at the feeding stations and on the feeding platforms. While no animals were seen eating the matured seed, the frequency of occurrence of empty fruiting calyces indicated that it is the seed for which the plant is cut. That this is an important plant in the diet of "bank rats" is shown by the numbers of plants cut, the distance the animals will travel to secure it, and the large number of localities in which dock

grows. Where both curly dock and cat-tails are available the dock appears to be the favorite. Only the artichoke (*H. tuberosus*) was eaten in preference to dock along many streams.

Bitter dock (*Rumex obtusifolius*).

Where this rather tough plant is available the base of the stems is eaten. As the plant grows on the dikes in the marshes it is fed upon by "marsh rats" as well as "bank rats." It is not an important food plant, as only a few of the more tender leaf stems are cut from each plant. As with *R. crispus*, it is possible that the mature seeds are eaten also.

Smart weed (*Polygonum acre*).

Muskrats cut large amounts of this weed in certain habitats. Very little of each plant is eaten, only a few of the internodes being consumed before the plant is discarded. However, where a small stream passed through an old pasture, large quantities were cut and transported to the feeding places. Such activities indicated that smart weed was forming an appreciable portion of the diet here.

Yellow pond lily, cow lily (*Nymphaea advena*).

In the bottoms, along ditches, and in certain marshy localities the yellow pond lily furnished considerable food. The base of the stems, the basal portions of the leaves and the fruiting body are eaten. Even the root is attacked where the food variety is not great. Possibly the root is of great importance in winter, but it is not much used in summer, except where pressure of numbers has reduced the available food supply. Wherever other plants such as *Typha*, *Nelumbo*, and certain of the sedges are to be had, the cow lily is not eaten to any extent. From these facts one is led to the belief that while it may form the staple diet where other plants are not available, the muskrat is not partial to it.

White lily (*Castalia sp.*).

The basal portion of the flower is eaten to some extent, though not many flowers are attacked. Hence, the muskrats do not destroy many blossoms, nor is the plant of any importance in their economy during the summer.

Water chinquapin, "lotus" (*Nelumbo lutea*).

At Buckeye Lake this plant proved to be the finest type of food plant for muskrats. In the early summer the stem furnishes food, while the leaves are used as a building material. The leaf stem is cut from one to two feet under water, and again an inch from the leaf. Only the central portion of the stem is eaten, the tough outer layer being removed and discarded. In removing this unedible material the stem is not stripped, but is uncovered by biting and pulling off small pieces an inch or an inch and a half long. These pieces were found frequently on the leaves of the *Nelumbo* where the rat had rested while making a meal. Later in the summer the "nuts" or seeds in the fruiting head are eaten. Oddly enough, few, if any, of the fruiting

stems had been cut before the seed ripened. As the root is farinaceous, it, too, may serve as food when green stuffs are not available.

Such an admirable food plant deserves attention from the ranchers of muskrats and state game commissions, for it will grow in water too deep for *Typha*, and is well liked. It should be planted extensively in waters where an additional source of food is wanted.

Water Cress (*Radicula nasturtium-aquaticum*).

A few stems of this spicy plant are eaten. There is very little wasted.

Sycamore (*Platanus occidentalis*).

In August some twigs and leaves of sycamore were found at feeding places, indicating that this tree furnishes food from time to time, but is not a constant source of supply like the willow or elm. This might have been due to the difficulty of securing the twigs rather than to any preference on the part of the animals.

Red clover (*Trifolium pratense*).

There is little waste when red clover is eaten, for a large portion of each plant is consumed. The flowering head is discarded, and it is from this that an idea of the amount utilized is formed. The extensiveness of the cuttings checked well with the number of heads, indicating that only the head was not consumed.

White clover (*Trifolium repens*).

This appears to be one of the favorites, if not the favorite plant, whenever it is available. In one old unused pasture well defined trails led from the stream to patches of clover. These trails ran back to the patches, spread out, and disappeared. These patches had been grazed down well below the level of the surrounding vegetation, and were kept down all through the summer. That this was not the work of woodchucks was evident from the small size of the paths, as well as their direction. Moreover, the woodchucks had been shot and trapped constantly over this area, so were rare or absent. Most of the clover was eaten on the spot, although some was carried to the stream.

This is an important food and one of the best of muskrat foods, as it is a favorite; and, since stems and leaves are eaten, there is little waste.

Sweet clover (*Melilotus alba*).

On the other hand, there is much waste where sweet clover is eaten, for the animals eat a small portion of the stem only. As the clover grows tough with the advance of the season, less and less is cut or eaten. Although abundant in some habitats, sweet clover is not a very important food plant; but when other food plants are scarce, as in an inclosure, muskrats have been known to eat the mature plant, roots and all.

Maple (*Acer sp.*).

Leaves and twigs of maple were found in feeding places along the Mohican during June, but no cuttings were seen. The leaves and some of the bark of the twigs are eaten.

Jewelweed (*Impatiens biflora*).

This is not an important source of food, although it appears from time to time on the piles of discarded foodstuffs. It is abundant along many streams and is easily available. Thus, much would be found at feeding places were it a favorite food.

Water hemlock (*Cicuta maculata*).

This plant may be poisonous to stock, but it is eaten by the muskrat. The stems are eaten, but the leaves discarded, so it is just possible that the stems lack some substance found in the leaves. The name, Musquash root, may indicate the recognition of the plant as a food supply of the muskrat. Not much is found on the feeding places, but neither is the plant itself abundant in any of the localities studied.

Spearmint (*Mentha spicata*).
Peppermint (*Mentha piperita*).

A few stems of each of these plants were found on several rafts. Only a few stems had been cut and only a small portion of each stem eaten.

Common plantain (*Plantago major*)

In early summer the base of the leaf stem and the tips of the leaves are eaten in considerable quantities. Later in the season the same parts of tender plants are consumed, as well as the fruiting heads of more mature ones.

Ironweed (*Vernonia sp.*).

The stems of ironweed are eaten. On July 22 the largest cuttings were found, which marked the period when most was consumed. Although some had been eaten before this date and some was eaten after it, this marked the period when ironweed was most abundant on the feeding rafts and in the accumulations in the water.

Boneset (*Eupatorium perfoliatum*).

Immature plants are eaten during July and August. Only the internodes are eaten, the leaves being discarded. While not a food of importance, considerable quantities are cut and taken to the water.

Golden-rod (*Solidago spp.*).

A small portion of stem about four inches above the ground is eaten. Very few plants are cut at any time, and none after blooming.

Aster (*Aster multiflorus*), (*Aster, spp.*).

Muskrats will travel as much as two hundred and fifty feet from the water to secure aster. Usually only the tops are cut off, which induces branching. In one plot this cutting of the tops had been done several times until the plants had taken on a bushy appearance; for not only had the tops been eaten, but the ends of the lateral branches had been eaten also. Even where abundant food is available, aster is eaten extensively.

Giant ragweed (*Ambrosia trifida*).

In June the base of the stem is eaten. Judging from the amount consumed ragweed is relished at this time of the year.

Roman wormwood (*Ambrosia artemisiifolia*)

A few plants of this species were utilized, the tender unfolding leaves at the top having been eaten.

Jerusalem artichoke (*Helianthus tuberosus*).

This very common plant was extensively eaten by the muskrats living along certain streams. On the Walhonding during the middle of June the stems of the artichoke were furnishing more food than all the other sources combined, sedges were second, and *R. crispus* was third. Great quantities of the artichoke had been cut, the leaves and nodes discarded, and the internodes of the plant eaten. Not only was more of this plant cut than all others, but more of each stem was utilized. The preference for this food was such that the animals passed other food plants close to the water to go over the bank to reach it. Many cuttings were found fifty feet from the water. This was not an unusual distance. After cutting off the stem about nine inches above the ground the plant was dragged to the feeding places. As this plant was growing luxuriantly on the tops of unshaded banks and along the edges of cultivated fields, its importance was evident. From the first of June until September the stems of this plant formed a very important item in the diet of muskrats wherever it was available. It is possible that the roots are eaten later in the season.

Yarrow (*Achillea millefolium*).

Although this plant was found at several feeding stations, only a little of the stem was eaten. It was cut before flowering.

White Lettuce (*Prenanthes alba*).

The internodes of a few plants had been eaten to judge from the remains at the feeding places. This plant, too, was cut before mature.

Corn.

Corn planted near marshes or stream banks is attacked. Before the stalk grows tough the basal portion is eaten. After the grain develops the stock is cut and the grain eaten off the ear where it lies. The cob may be carried to the water or den for consumption.

Wheat.

The amount of damage done by muskrats to ripening wheat is not nearly so great as that done by the woodchuck. The muskrat cuts the stalks and removes the unripe grains. Usually the cut stalks are carried to the water before being eaten.

Oats.

Some oat stalks were found along a stream which ran between a field of oats and a field of wheat. Wheat was preferred, evidently, since very little oats had been cut.

Mussels.

While many mussel shells were seen bearing marks and heaps of shells were seen near feeding places, the species of mussels are not listed, since the evidence was purely circumstantial.

Muskrats.

Muskrats killed on unfrequented roadways by passing cars were found to have been eaten by their fellows. This statement is based upon the collection of feces about such carcasses. Just why the animals should pass over an exposed roadway instead of going under a bridge is difficult to understand. Nevertheless, many banks showed well defined trails leading over the bank to cross the road. On one occasion three animals were seen to use such a trail within the hour, while not one animal was detected passing under the bridge during that period.

LITERATURE CITED.

1. **Arthur, Stanley C.** 1928. Seventh Biennial Report, Dept. of Conservation of Louisiana, 1924–1926.
2. **Johnson, C. E.** 1925. The Muskrat in New York. Roosevelt Wild Life Bulletin, Vol. 3, No. 2.
3. **Svihla, A.** and **R. D.** 1931. The Louisiana Muskrat. Jour. Mammalogy, Vol. 12, No. 1, pp. 12–28.
4. **Ulbrich, Hans.** 1927. The Food and Economic Significance of the Muskrat. (a) Food. Kranke Pflanze, 3 (2): 27–30, 1926.

POECILICHTHYS OSBURNI, A NEW DARTER FROM THE UPPER KANAWHA RIVER SYSTEM IN VIRGINIA AND WEST VIRGINIA.

CARL L. HUBBS AND MILTON B. TRAUTMAN.

The handsome percid named and described in this paper is the fifth species of fish to be indicated as characteristic of the upper Kanawha system. The others, all cyprinids, are *Notropis scabriceps* (Cope), *N. kanawha* Jordan and Jenkins, *Phenacobius teretulus* Cope and the recently described *Parexoglossum lauræ* Hubbs (1931). All of these species occur, so far as known, solely in the Kanawha River basin above the Kanawha Falls, the position of which is indicated by the arrow in Fig. 1. This upper Kanawha River system, the outlines of which are indicated by the black line in Fig. 1, is in other ways set apart, from the standpoint of fish distribution, as one of the most distinctive subdivisions of the vast Mississippi system.

The Upper Kanawha system is a cut-off portion of the Ohio River system, which is the chief home of *Poecilichthys variatus* (Kirtland), the only species with which *P. osburni* is closely related. The range of *P. variatus* is also indicated, by record stations and by assumed limits, in Fig. 1. The basis for mapping the distribution of *P. variatus* may now be indicated by states:

DATA ON THE DISTRIBUTION OF *POECILICHTHYS VARIATUS*.

All records refer to the Ohio River system, except for the single record stations each in Arkansas and Missouri.

NEW YORK.—Recently collected by Dr. John R. Greeley in French Creek, in Chautauqua County, near the western boundary of the state.

PENNSYLVANIA.—Recorded by Bollman (1886: 339); McConnell (1905: 178); Fowler (1919: 70), and Fowler and Carlson (1927: 72). We have no reason to doubt the validity of any of these reports, although only the specimens recorded by Jordan have been seen. One new record for the state, for French Creek, near the New York state line, is indicated on the map. Specimens were recently taken there by Dr. Greeley.

OHIO.—This species was originally recorded from the Mahoning River by Kirtland (1838: 168 and 192), who added, "I am indebted to Mr. Charles Pease for a specimen of the same species taken in the Cuyahoga," which is a small river entering Lake Erie at Cleveland. Unfortunately this record is probably incapable of verification because the stream is now badly polluted. The doubt as to the validity of this record is increased to an almost certain indication of error when we recall that Kirtland mentioned only the Mahoning

River in describing the species (1840: 274, Pl. 2, Fig. 2); that he did not recognize the species now known as *P. coeruleus* until 1854 (p. 4); that he in 1850 (p. 1) recorded *variatus* not only from the Mahoning and Scioto rivers, but also from Chicago, Illinois, and that he, according to Jordan (1885: 163) later regarded Storer's *Etheostoma coerulea* as identical with his own *variatus*. These circumstances warrant us in questionably referring Kirtland's two records of *variatus* from the Great Lakes drainage to *Poecilichthys coeruleus*, which is there the most abundant of bright-colored darters. A few other Ohio records of *P. variatus* are given by Henshall (1888: 80), Osburn and Williamson (1898: 20) and Osburn (1901: 97), but the majority of the records indicated in Fig. 1 were made recently by the Lake and Stream Survey of the

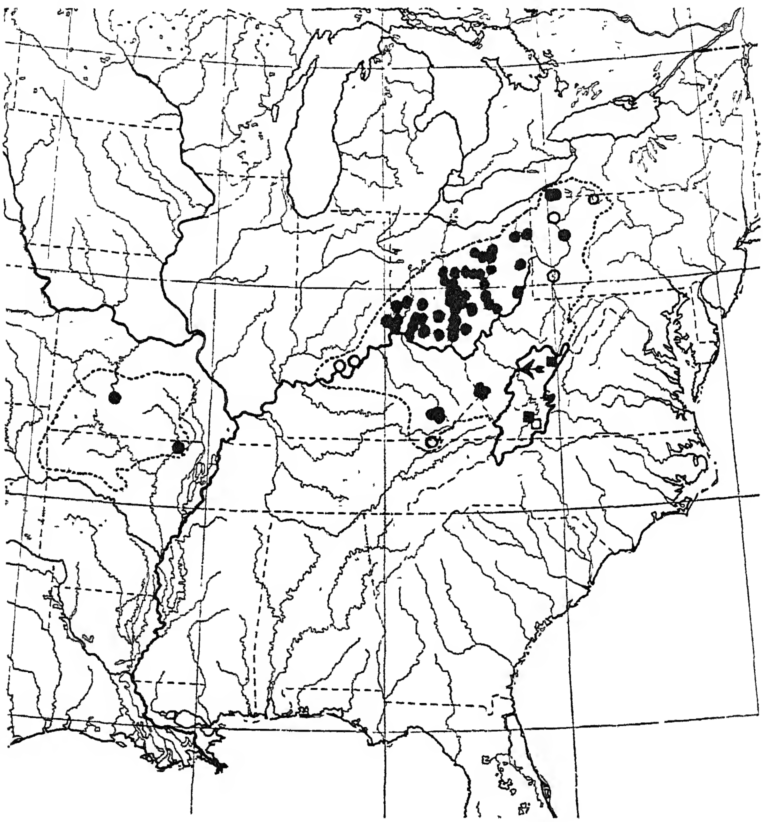

FIG. 1. The distribution of *Poecilichthys osburni* and *P. variatus*.

The supposed range of *P. osburni*, surrounded by a solid line, is the drainage basin of the upper Kanawha system, above the Kanawha Falls, which are located by the arrow.

The range of *P. variatus* as now provisionally determined is surrounded by broken lines.

The solid squares locate the two record stations of typical *P. osburni*.

The hollow square locates the locality where the variant type of *P. osburni* was found.

The solid circles indicate the confirmed record stations for *P. variatus*.

The hollow circles represent the unconfirmed record stations for *P. variatus*.

Ohio Division of Conservation. Other reports of *variatus* for Ohio, as Jordan's (1882: 973), refer either to *Poecilichthys coeruleus* or to *Hadropterus maculatus* (see Jordan, 1885: 163).

INDIANA.—Reported by Jordan (1885: 163, Evermann (1886: 8); Evermann and Bollman (1886: 339); Woolman (1892: 280); Hay (1894: 278), and Cockerell (1913: 156). Some doubt pertains to the last record, which may have been based on specimens holding over on erroneous identification.

WEST VIRGINIA.—Neither Goldsborough and Clark (1908) nor other authors have recorded *Poecilichthys variatus* from West Virginia. The junior author, however, has seen specimens recently taken by John Addair in the Guyandot River at Justice City, Mingo County; in the Tug Fork at Gates in the same county, and at Mohawk in McDowell County, and in Pigeon Creek, an eastern branch of the Tug, at Delborton, Mingo County. We are obliged to Mr. Addair for permission to announce his discovery of this darter in West Virginia. In West Virginia, *P. variatus* is apparently generally distributed except in the territory of *P. osburni*—the Kanawha basin above the falls.

KENTUCKY.—Recorded by Woolman (1892: 280), and Evermann (1918: 358). Some of Woolman's specimens have been re-examined. Evermann's record for the South Fork of the Cumberland was of course based on *P. coeruleus*, which in 1878 passed under the name of *variatus*.

TENNESSEE.—Evermann and Hildebrand's (1916: 450) record, the only one for the state and for the distinctive and rather well-worked fauna of the Upper Cumberland system, though indicated as a hollow circle on our map, is not accepted without reservation. The record was accompanied by no description and was based on only one specimen, which we have not been able to relocate.

ARKANSAS.—The only published records of *P. variatus* for any locality outside of the Ohio basin are (1) the doubted one for Easton, in the Delaware system of Pennsylvania (Jordan and Evermann, 1896: 1070), which record is indicated as surely erroneous by the finding of other western species in the Museum of Comparative Zoology similarly mislabelled "Easton, Pa." and (2) the record for the Arkansas River drainage of Arkansas by Hubbs and Ortenburger (1929: 48).

MISSOURI.—This Arkansas record station is rendered less isolated by the recent finding of this species in the Missouri River system of Missouri, by J. Clark Salyer. The specimens, corresponding well with topotypical ones of *variatus*, were collected in the Niangua River drainage near Marshfield, Missouri.

The intimate relationship of *P. osburni* with *P. variatus* is conclusively testified to by the agreement in many highly distinctive features of structure, form, color and habitat. They agree in having the anal fin unusually large and long, almost as large as the second dorsal fin, and the pelvic fins rather widely separated, for a species of the large group now usually thrown together as the genus *Poecilichthys*, in these respects approaching or resembling the forms of *Ulocentra*, *Hadropterus* and related genera. The two species further resemble one another in being, for their group, rather large and robust, heavy-finned fishes. In the male colors they agree in many features, notably in having bright orange vertical bars, an orange-carmine horizontal band on the lower sides anteriorly and scattered carmine spots on the pectoral fin. In both sexes, but most conspicuously in the young, the body in both species is marked by regular, oblique blackish saddles, much like those of the hog sucker *Hypentelium*. Agreement between the two species is close also in squamation, number of fin rays, etc. In correlation with their characters, both species inhabit extremely swift water, living among stones and boulders in rapids. The close relationship of *P. osburni* with *P. variatus* can scarcely be questioned.

The differences between *osburni* and *variatus* are nevertheless striking. *P. osburni* is the more terete; less arched and less elevated at the shoulders, and usually more slender (in adults the depth is contained in the standard length, 4.85 (rarely 4.55) to 5.3 times, instead of 4.3 to 5.0 (rarely 5.2) times). In *osburni* the snout is sharper and longer than in *variatus*, less bluntly decurved, and the eye is smaller; as a consequence, the eye is contained 1.2 to 1.5 times in the snout, instead of 0.9 to 1.0 times. The eye is contained in the head 4.0 to 5.2 in contrast with 3.4 to 4.05 times. The head averages smaller than in *variatus* (contained 3.7 to 4.2 as opposed to 3.4 to 4.0 times in standard length). The gill-membranes in *osburni* are less broadly united across the isthmus than are those of *variatus*, forming a sharper indentation posteriorly. The posterior part of the breast is usually scaleless in *osburni*, usually scaled in *variatus*. Numerical differences in number of scales, fin-rays and color markings are:

	P. osburni	*P. variatus*
Scales above lateral line	8 to 10, usually 9	7 or 8, usually 7
Scales along lateral line	58 to 68	50 to 58
Scales below lateral line	12 to 14, usually 13	11 to 13, usually 12
Dorsal rays	XI to XIII, 13 to 15	XI to XIII, 12 to 14, usually 13[1]
Anal soft rays	9 to 11, usually 10	9 or 10[1], usually 9
Black saddles on back	5	4
Orange bars in male	11 or 12	5 or 6

The boldest of the differences in the colors of the males involves the orange bars. The yellow area, carmine-centered, which extends from the pectoral to the anus, is encroached upon from above by the anteriormost of the orange bars in *osburni*, whereas in *variatus* this area, as also the space above it, is free from these bars, which in that species are restricted to the posterior part of the body. The dark saddles are less solid and less blackish, and more tesselated, in *osburni* than in *variatus*. The yellow blotch on the cheek of the male is much more conspicuous than in *variatus*, in which it is represented merely by a lightening of the ground color, and centers in a bright red spot which is not evident in that species.

P. osburni apparently attains a larger size than *P. variatus* by about a centimeter. Our largest specimen is 86 mm. long to caudal fin.

We now proceed with the description of the new species.

Poecilichthys osburni, new species.
Kanawha darter.

Holotype: Cat. No. 92409, Museum of Zoology, University of Michigan, is a male 75 mm. long to caudal base, collected in Stony

[1]One aberrant specimen from Ohio showed 16 soft dorsal rays and 11 soft anal rays; unconfirmed counts given in the literature give the dorsal spines as high as 14 and the anal soft rays as low as 7.

Creek, a tributary of the Greenbrier River, Pocahontas County, West Virginia, by John Addair, on June 2, 1931.

Paratypes: Seven male and female adults 60 to 86 mm. long, collected with the holotype; 2 males collected about a year previously at the same place; a female (39542, U. S. National Museum), collected many years ago by McDonald in Reed Creek, Virginia, and 7 male and female adults collected in the same stream, which is a western tributary of the New River, by Carl L. Hubbs and Edwin P. Creaser, on May 17, 1931, at a point two or three miles below Max Meadows, Virginia, at an elevation of 1,950 feet. The paratypes are deposited in the Ohio State Museum, National Museum and the Museum of Zoology, University of Michigan.

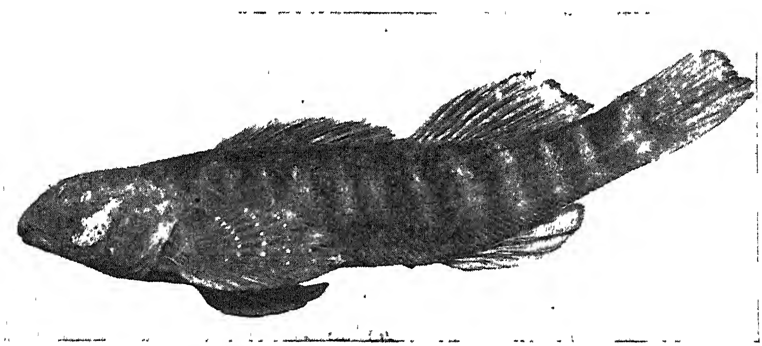

FIG. 2. *Poecilichthys osburni.* (A retouched photograph of the holotype.)

The courtesy of Mr. John Addair in allowing us to describe this darter is gratefully acknowledged.

The body is rather terete, as its greatest width is contained 1.4 times in the greatest depth. The anterior dorsal profile rises rather abruptly, though not so abruptly as in *P. variatus*, from the tip of the snout to above the eye, continuing to rise very gently to the middle of spinous dorsal, then curving gently downward to the rather deep caudal peduncle. The ventral contour approximates but is less curved than that of the dorsal. The mouth is rather small, low, subhorizontal, with included lower jaw. The teeth are small and subequal, and in rather broad bands on the jaws; there are teeth on the vomer. The premaxillary is non-protractile. The cheeks are rather conspicuously tumid. The preopercle is entire; the opercular spine is sharp. The gill-membranes meet at a somewhat acute angle, although they are still broadly joined.

The head is entirely devoid of scales (in *variatus* there are occasionally a few scales on the upper part of the opercle). The breast is also scaleless (rarely partially scaled near the ventral fins; this region is usually scaly in *variatus*). The lateral line is complete (occasionally a pore is missing).

The fins are all large. The two dorsals are joined (slightly separated in some paratypes). The highest dorsal spine is contained 1.35 times

in the highest soft ray. The pectoral fins are slightly longer than the head, and comprise 15 (rarely 14 or 16) rays, as in *variatus*. The caudal fin is subtruncate, slightly emarginate, with broadly rounded lobes.

This species is surely one of the most beautifully colored of the darters. The prevailing colors of the type and other adult males (described from fresh specimens in formaldehyde) are various shades of dark green and orange. The darkest color, a blue-black, appears on the occiput and on a vertical bar from the eye downward. The opercles are also very dark. The cheeks are largely occupied by a rhomb of bright yellow, grading into red medially. In front of the subocular bar is a similar though less conspicuous mark, obscured in high males. The middle of the snout is flushed with red. There are strong flushes of yellow on the lower surface of the head. The branchiostegal membranes are light yellow, and there is a bar of orange on either side of the midline, near the base of the lowest branchiostegals. The membrane between the mandibles is light yellow, while the rami themselves are metallic blue.

Twelve deep greenish-blue bars cross the trunk along the side of the body, not counting the large blotch at the caudal base, which together with a dark shade across the base of the caudal forms a more or less definitely triangular mark. The dark bars almost completely encircle the body behind the anus, and are rather narrowly conjoined dorsally. The twelve intervening light areas (not counting the dash of light behind the occiput), narrower and shorter than the blue bars, are deep orange. The lower third of the side of the fish, from just behind the pectoral base to near the anus, carries a brilliant horizontal blotch, grading from yellow at the edge to a brilliant orange-carmine medially; a most striking color feature, shared only with *P. variatus*. Medially the belly is pale. The breast is blackish blue between a pair of bright yellow spots which lie just below the pectoral fins.

The spinous dorsal is largely covered by a crescent of deep greenish-blue, paler on the spines than on the membranes; the basal crescent is lavender-gray, with a wedge of purplish brown on each membrane; the margin is a yellow band becoming an intense orange medially. The soft dorsal is dusky blue on the webbing, grading outward into gray within the sooty border; the gray portions of the membranes contain streaks of fire-orange; the rays themselves on their basal halves are scatteringly spotted with bright orange-red spots. The caudal is similar to the second dorsal, but the basal color is much lighter and the red spots are much more intense. The anal fin is green-blue on membranes of basal two-thirds; the rays outward are orange yellow, producing an interrupted band; the margin of the fin is milk-white anteriorly, but becomes sooty on membranes posteriorly. The pelvic is blackish green-blue, with the edges of the rays gray, and the spine and the outer border milk-white, and with some orange near border laterally. The pectoral fin is the lightest of all and the most brilliantly spotted with fire-orange; these spots are in three or four curved grayish streaks, which separate the green-blue ground color of the rays into rather definite curved bands; the outer part of the fin is yellowish on the rays.

Less developed males are not so brilliant, and the color pattern is less distinct and approaches that of the females. In that sex and in the young males the broad greenish and orange bars of the sides are much disrupted and more or less obsolescent anteriorly, and extend but little above the lateral line, where they tend to be truncated by a light greenish streak. The shoulder region and the head are colored much as in the males, but the orange bars on the branchiostegals are smaller and browner, and the orange on the cheek is diffused over the diamond-shaped whitish area. The spinous dorsal is not quite so bright as in the males, but the main band is a clearer green. The soft dorsal is also similar to that of the males, but lighter, and with rows of greenish black spots near the base. The pectoral and caudal fins are banded with dusky green and clear transparent orange. The pelvic and anal fins are cream-yellow, with whiter borders.

An outstanding feature of the species is the development of black saddles, similar to those of *P. variatus*, but less solid, more tesselated by blackened scale borders, and more numerous; there are five instead of four, the extra one being accounted for by the presence of two instead of only one on the caudal peduncle. An imperfect saddle also appears below the middle of the spinous dorsal, in a region where scarcely any darkening is evident in *variatus*. The most conspicuous saddles, as in *variatus*, are those just before the spinous dorsal, in the region between the dorsals, and below the posterior part of soft dorsal. The first saddle, fused with the first dark bar, is continued to the axil of the pectoral fin.

The young closely approach *Boleosoma* in color pattern.

Measurements and counts of holotype: Head, 3.85; depth, 5.0; eye in head, 4.6; eye in snout, 1.5; bony interorbital, 2.7 in eye; least suborbital width, 6.2 in head; upper jaw, 3.6; highest dorsal spine, 1.4 in highest dorsal soft-ray, 2.2 in head, 2.5 in first dorsal base; highest dorsal soft-ray, 1.4 in head, 1.1 in base of second dorsal; length of caudal fin, 1.5 in head; highest anal ray 1.2 in base of fin, which is contained 1.2 times in base of dorsal and 1.7 times in head; length of longest pectoral ray, 0.95 in head, of pelvic fin, 1.7. Dorsal rays, XIII–13; anal, II, 9; pectoral, 15. Scales, 8–64–13.

Variants.—Two specimens, 30 and 45 mm. long, from Big Reed Island Creek, at an elevation of 2,500 feet, just below an old mill dam in Carroll County, Virginia, collected by Hubbs and Creaser in 1931, resemble the smaller paratypes, but differ notably in having the dark markings more tesselated and disrupted, and the scales much larger, as large as in *P. variatus*. Otherwise they are very similar, and probably represent merely a local race. It is of interest that they were taken in a creek which flows into the New River almost opposite Reed Creek, where typical *osburni* was taken.

Some measurements* and counts of the two aberrant specimens follow: Head, 3.5 and 3.9; depth, 6.0 and 5.1; eye in head, 3.7 and 4.0; eye in snout, 1.0 and 1.25; dorsal rays, XI–12 and XII–13; anal rays, II, 8 and II, 9; pectoral rays, 15 in each; scales, 7–54 and 57–11.

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*In comparing these measurements with those previously given, allowance must be made for the fact that these specimens are immature.

We are happy to associate with this species the name of Dr. Raymond C. Osburn of Ohio State University—long fond of the exquisite little percid fishes known as darters—in recognition of the contributions he has made, by study and encouragement, to the advancement of our knowledge of the freshwater fishes of interior North America.

LITERATURE CITED.

Cockerell, T. D. A. 1913. Observations on Fish Scales. Bull. U. S. Bur. Fish., 32, 1912: 119-174.

Evermann, Barton Warren. 1918. The Fishes of Kentucky and Tennessee; a Distributional Catalogue of the Known Species. Bull. U. S. Bur. Fish., 25, 1915-1916: 295-368.

Evermann, Barton Warren, and **Bollman, Charles H.** 1886. Notes on a Collection of Fishes from the Monongahela River. Proc. N. Y. Acad. Sci., 1886: 335-340.

Evermann, Barton Warren, and **Hildebrand, Samuel F.** 1916. Notes on the Fishes of East Tennessee. Bull. U. S. Bur. Fish., 34, 1916: 431-451.

Fowler, Henry W. 1919. A List of the Fishes of Pennsylvania. Proc. Biol. Soc. Wash., 32: 49-74.

Fowler, Henry W., and **Carlson, J. Gordon.** 1927. Fishes from McKean, Potter and Cameron Counties, Pennsylvania. Proc. Biol. Soc. Wash., 40: 65-74.

Goldsborough, Edmund Lee, and **Clark, H. Walton.** 1908. Fishes of West Virginia. Bull. U. S. Bur. Fish., 27, 1907: 29-39.

Hay, O. P. 1894. The Lampreys and Fishes of Indiana. Ind. Dept Geol. and Nat. Res., 19: 146-296.

Henshall, James A. 1888. Contributions to the Ichthyology of Ohio, No. 1. Jour. Cinn. Soc. Nat. Hist., 11: 76-80.

Hubbs, Carl L. 1931. *Parexoglossum laurae*, a New Cyprinid Fish from the Upper Kanawha system. Occ. Pap. Mus. Zool. Univ. Mich., 234: 1-12, fig. 1, pl. 1-2.

Hubbs, Carl L., and **Ortenburger, A. I.** 1929. Further Notes on the Fishes of Oklahoma with Descriptions of New Species of Cyprinidae. Publ. Univ. Okla. Biol. Surv., 1 (2): 15-43.

Jordan, David Starr. 1877. Contributions to North American Ichthyology Based Primarily on the Collections of the United States National Museum. Bull. U. S. Nat. Mus., 10: 1-120.

1882. Report on the Fishes of Ohio. Geol. Sur. Ohio, 4: 738-1000.

1885. On the *Etheostoma variatum* of Kirtland. Proc. U. S. Nat. Mus., 8: 163-165.

Jordan, David Starr, and **Evermann, Barton Warren.** 1896. The Fishes of North and Middle America, Part 1. Bull. U. S. Nat. Mus., 47 (1): 1-1240.

Kirtland, J. P. 1838. Report on the Zoology of Ohio. Sec. Ann. Rep. Geol. Surv. Ohio: 157-160, 168-170, 190-197.

1840. Descriptions of the Fishes of Lake Erie, the Ohio River and their Tributaries. Boston Jour. Nat. Hist., 5: 265-276.

1850. Fishes of Ohio. The Family Visitor, Cleveland, 1: 21.

1854. *Poecilichthys erythrogastrum.* The Annals of Science, Cleveland, 2 (1): 4-5, 1 fig.

McConnell, ———. 1905. "Rep. Comm. Fish. Pa., 1905, p. 178" (quoted from Fowler, 1919: 70).

Osburn, Raymond C. 1901. The Fishes of Ohio. Ohio State Acad Sci., Spec. Pap. 4: 1-104.

Osburn, Raymond C., and **Williamson, E. B.** 1898. A List of the Fishes of Franklin County, Ohio, with the Description of a New Species of *Etheostoma.* Sixth Ann. Rep. Ohio St. Acad. Sci., 11-20.

Woolman, Albert J. 1892. Report of an Examination of the Rivers of Kentucky, with Lists of the Fishes Obtained. Bull. U. S. Fish. Comm., 10, 1890: 249-292.

GEOGRAPHIC CONDITIONS, INFLUENCES, CONTROLS.*

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OUTLINE.

By practice and now by definition the field of Human Geography is the relationship between the man and his environment. Many types of terms are employed to express and describe the nature of these relationships, such as conditions, influences, controls, principles and laws. Man is always among conditions. In some circumstances he is influenced by them. To these influences he responds at times by adjusting or adapting himself and his activities, at other times by modifying the conditions to suit his needs. It may be in more circumstances than we are willing to admit there is a real geographic determinism, so strong that a people cannot escape it, an absolute control. This paper reviews many terms used in the literature of the last twenty-five years, discusses and strives to evaluate them.

The works of many authors, mostly my personal friends, have been read and from their books and papers excerpts have been taken. From the nature of the case the setting could not be included with the sentence or phrase used in this paper. Desire to represent exactly what the book said has been uppermost in my mind. If misrepresentations have in the least degree entered anywhere, apologies are offered and forgiveness asked. No other way to make such a study as this could be discovered and yet the need for such a study has impressed itself upon my mind for a number of years. Therefore I have

*This paper was presented to the Annual Meeting of Association of American Geographers at the New York meeting, 1928–29.

proceeded for my own benefit and now for the benefit I trust of all of us who read the paper. Let us here take stock together of our own product and see if we can improve it in any way.

As to method of work, the various phrases used in the literature read, which express the relationship between man and his surroundings were jotted down with the reference. These terms and phrases were then grouped under several headings which now appear as headings in the paper. These brief quotations are the basis for the paper. By italicizing the significant word or phrase it is easier to pick it up quickly. Comments weave the series together and conclusions are drawn from the study.

GEOGRAPHIC CONDITIONS.

Jones and Whittlesey (1) raise three questions. (1) Are the economic activities of a country *determined* by the natural environment of the region? (2) Are they *influenced* by the environment? (3) Are they *closely related* thereto? "Determine" is a good word because every economic activity is not only influenced but is determined. If it is not determined, it could not be. The question then is, by what is it determined? It were well then to answer the first question by saying the physical environment is significant in *helping* to *determine* the economic possibilities and activities of a region. There are other factors.

If the soil, climate and topography help to determine, they do have an influence and we can answer the second question—yes. Further, if they influence the economic activities so far as to help determine what they shall be, they must be closely related. The last question then could always be answered in the affirmative, the middle one no doubt is truly answered the same way, but the first as it stands is not ready for an unqualified affirmative.

It would be fair to say that every human activity has Geographic conditions. On the same page as the questions may be found another statement. "The earth is the stage on which men live and work." But the authors do not consider the man passive to the stage, for they continue, "the broad limits within which life functions therefore are set by the natural environment. That changes but little from generation to generation even though succeeding generations make very different uses of it. But all the uses are within the limits.

Man may make and does make a choice as to how his economic life is ordered within the limits set. Sometimes he chooses wisely, sometimes not. With different knowledge and ideals, different stages of culture and needs, he chooses to make different uses."

Would it not be wise then for man to know his geography? To be as familiar as possible with the capacities and limits of his stage that he may avoid as many mistakes (bad choices) as possible?

It has been said that geography deals with the natural environment as related to man: some say as the home of man. Smith (2) would say study human activities as *affected* by the earth, rather than study parts of the earth as they *affect* human activities. Febvre (3) points out that the older historians pictured man, armies, and nations as *always* enduring and *never* acting, but joins with the others in these modern studies in believing that there are relations between man and the environment which the stage idea and that of simple conditions cannot interpret.

INFLUENCES AND RESPONSES.

If there are influences they must be met by response or resistance. Huntington and Williams (4) recognize influences. We read, "the aim is to give a clear conception of the way in which geographic conditions influence the products of a region, the capacity of the people, the direction in which their activities are turned, and the nature and extent of their business relations with other regions." Johnson (5) discusses in each chapter a great manoeuver on some front and "deals with the more striking surface features *affecting* military operations," "emphasizes the *influence* of land forms." He calls this influence a *relationship* on the previous page.

Peattie (6) says "the relations are essentially environmental *influences*." "These types of factors are the ones that *influence* the value of fields and their height limit," p. 362. "People *react* differently to the same influences during different stages of their culture or civilization," p. 6. Huntington and Cushing (7) assert "plants, animals and soils *influence* man," "man *responds* to geographic surroundings." "Man is constantly learning to overcome the influence of unfavorable circumstances and is even causing them to help him." Davis (8) speaks of *responses*, but they are not to *influences*, rather to *controls*.

Smith (9) raises the question, "How does North America *influence* man as he makes his living and lives his life upon it?" It takes the book to answer, and he is pretty consistent in sticking to the term or the spirit of the term *influence* all through.

Ridgley (10) uses the word *influence* occasionally, but leans to the other side—the *response* idea, and uses much more freely the word "*tends*." "Cities *tend* to develop wherever there is a break in transportation," p. 10. "Where coal and iron ore are in different regions the ore *tends* to go to the coal," p. 123. He seems to follow Cooley (11) in this, for Cooley says, "population and wealth *tend* to collect wherever there is a break in transportation." This term becomes monotonous but has the advantage of indicating the direction of the influence. Fairbanks (12) does not use the word *influence*, but *responses* and *relationships*. He says, "*relationships* is the unifying idea at the root of all true geography," "Method of interpretation is the essential thing," "Pupils can reason out life *responses* to physical environment in other parts of the world after knowing similar *relations* in the home region."

Miss Newbigin (13) says, "the necessity for finding the metals best suited to his use . . . has always *influenced* the movements and the settlements of men." While on the same page she speaks of the "distribution of minerals being of great importance in *determining* the distribution of man," she has no spirit of geographic determinism, but recognizes the relationships as influences. In another book she says, "The significance of (geography) lies not in separate facts . . . but in that they have to be considered in their inter-relations. . . . Students cannot acquire too soon the habit of linking the great facts of climate and relief with the life of man." She adds, p. 19, "Human geography may be defined as the study of the . . . *action* and *reaction* between man and nature."

RELATIONS AND INTER-RELATIONSHIPS.

Miller and Parkins (15), p. XII, reads, "Geography as relationships between natural environment and life," "Geographic environment does not explain everything," "Probably no one thing (cause or factor) explains any particular phenomenon in life." Here as in many references "relation" is used instead of influence, but it is about as non-commital. It may be a relation expressed in man's response or adjustment to the

conditions or it may be a relation expressed in man's modification of the environment. It is indefinite.

Jefferson (16) makes it clear in a number of illustrations that the same place has called forth very different *responses* from different people at successive times, thus illustrating interrelations and at the same time the fact that the mind of man has something to do with the nature of the response. For example, he points out that the American Indian in the Great Lakes region was essentially a fisher and hunter, the Frenchman was a hunter and a missionary, the mixed Europeans later were general farmers, raised corn and built cities, but he does not tell us the nature of the relationship. Was it helpful to man, or otherwise? Obviously each man used what he wanted in the way he wanted to; but neither Jefferson nor Vidal de la Blache, who used the same illustration, points out how the region helped the man, presented obstacles to him and spurred him on to his characteristic activity. One must not be satisfied with simply discovering influences, or relations. He should show how the conditions are related to the man and how the man is related to the conditions.

Again on p. 32 the same author finds the North Central Plains of Europe supporting lumbermen in the middle ages after a reign of huntsmen and fur gatherers, then producing great crops of wheat, oats, potatoes and rye for the agriculturists. While all this continues in the plains, man has recently tapped the mountains for mineral wealth and now the plains support great industrial cities. But in all the page the only word stating the nature of any relationship is "*prevents*," referring to mountains not high enough to keep out roads and railroads. In this case one can easily infer that the relationship in these latter days is considered to be quite *advantageous* to man.

In her preface Newbigin (14) reads, "the relation between groups of men and the character of the lands in which they have established themselves." This is the general statement introducing the later studies where the nature of the relations is very adroitly disclosed.

Brunhes (17) says, "Human Geography is a study of the relationships between human activities and the phenomena of Physical Geography . . . soil, climate, circulation of water, vegetation and animal life on the one hand, human establishments, ways of travel, cultivation, breeding, exploitation

of natural resources on the other are united by bonds of causality more or less apparent by connections more or less close. . . . " Again, "Human phenomena which *inscribe* themselves on the soil, and which *modify* nature at the same time they *are modified* or brought about by nature." These quotations are both from the preface. They are the general statements, the broad undisturbed generalizations.. In the body of the book where specific regions or types of houses are discussed the relations are much more specifically expressed.

Jones and Bryan (18), p. 3, assert, "we must grasp the significance of this interrelation of man and his environment," but they speedily slip far beyond the zone of influence into the field of determinism and control to be discussed below.

Unstead and Taylor (19) start well. In the preface we read, "The treatment is as far as possible causal and no facts are given without explanation." This is certainly a recognition of relationship in geography. In the text, facts of physical geography are often very well explained, but it is quite difficult to find real geographic material in the human relations, even through large sections of the book. Facts of environment are stated, then facts of ontography, but the nature of the relation is too often left to inference.

Febvre (3), p. 361, is clear cut. "What are the *relations* between human societies of today and their present geographical environment? That is the fundamental problem and the only one which human geography sets itself." And one has but to turn to his inspiring chapter on Communications to discover how lucidly he interprets the relations into "*forbidding*," "*attractive*," "*inhospitable*," "*hindering*" and "*favorable*" relations. He rarely leaves one in any doubt in specific cases what the real nature of the relationship is.

CONTROLS AND GEOGRAPHIC DETERMINISM.

In working over the literature for this point of view surprises have been found. It is no more than fair to some authors to say that were they writing today they probably would couch their ideas in different words. It is also true that *controls* and *dominations* are in degrees of intensity.

Johnson (5), p. III, "To emphasize this interesting relationship between inanimate nature and the Science of War" is followed by, p. 1, "The violation of Belgian neutrality was predetermined by events which took place in Western Europe

several million years ago. . . . nature was fashioning the scenery which was not merely to serve as the setting for the European drama, but was, in fact, to guide the currents of play into blackest tragedy." "If . . . Germany would not have been tempted to commit . . . The surface configuration of Western Europe is the key to events in the theater of war." This author in succeeding paragraphs gives due credit to ambitions, ideals, and covetousness and thereby suggests that the trouble was not wholly in the topography.

Ratzel is perhaps the strongest advocate of Geographic determinism, but his work and that of some of his predecessors may be excused in part by the lack of knowledge in the science. No quotations will be made.

Vidal de la Blache (20) says, p. 17, "It most often happens, with slight obstinate exceptions, that the *sovereign* influence of environment has *forced* all Europeans into similar occupations and customs." "Some societies have long been part of the environment, but others are in process of formation, continuing to recruit members and to be modified day by day. Upon such in spite of all they can do, surrounding conditions leave their impress, and in Australia, at the Cape, or in America these people are slowly becoming saturated with the influences of the regions where their destinies are to unfold." Again on pp. 29–30, "Increase of population always encounters serious obstacles, many of them insuperable; . . . some of them are superabundance of vegetation and insect life or insufficiency of moisture or heat." Perhaps this is not meant for absolute determinism and should simply be dated to save it. 'Insuperable' today is a challenge and may not be at all insuperable tomorrow. In fact this geographer, p. 20, gives us a redeeming picture. "The task of colonization—glory of our age—would be only a sham if nature set definite rigid boundaries instead of leaving a margin for the work of transformation or separation which it is man's power to perform." This introduces another point of view less absolute, p. 19: "Man is at once both active and passive," "Relation takes the form of man's transforming the environment."

Brunhes (21), p. 58, writes, "According as human groups are placed in this or that geographic setting they are *led* or *impelled* to grow certain crops, here horses, there palms and rice, here cattle and there sheep; and each type of activity brings about its own type of social organization." Perhaps

he meant more of a *control* existed than is suggested by the translation "led," but if so it would hardly be in keeping with his other interpretations.

Miller and Parkins (15), p. 55, reads, " . . . future national leadership in air and sea may be *determined* by the possession of fuel oil. . . . " This factor may help to determine.

But Jones and Bryan (18) use the word *control* even more than these American and French authors. In preface, p. VII, "author's aim has been to indicate the nature of the controlling geographic facts." p. V, "The peopling of the continent by Europeans began so early as to suffer a very complete measure of geographical control." "In every stage of development of these new lands (America) the shape and size, the winds and currents, of the Atlantic ocean have been *controlling* factors and it is to our purpose to study the nature and operation of these *controls*."—p. 3.

"Geographic factors which were *limiting* Spanish so largely to Southern Mexico." "The *dominating* factors here are very simple."—p. 31. "Position of early French settlements, in North America, were *largely controlled* by the nature of the St. Lawrence and Mississippi rivers."—p. 42. "Geographic conditions obtaining in New France very *largely controlled* the nature of settlement."—pp. 54–5. "In spite of . . . (several items mentioned) they (New England colonists) followed a mode of economic development *almost completely controlled* by their geographic environment."—p. 66.

Davis (22) wrote, "The fact that Celtic is still spoken in rough, distant, or isolated parts of Great Britain because of their roughness, distance and isolation is a local example of an important class of relations between controls and responses." This quotation is given as an illustration of the "third position which would treat ontography as thoroughly as physiography and would search for all the geographical relations of physiographic *controls* and ontographic *responses*." Subsequently the author records that he has adopted this third position.

Huntington and Williams (4) have several paragraph heads in *control* terms. p. 19, "How relief *controls* the nature of the products." p. 98, "How physical conditions *determine* the detailed location of trade routes." Also sentences in the paragraphs under the headings, "After general location has been *determined* by centers of human activity, details are *determined* by physical conditions," and "Since relief has a *dominating*

influence upon transportation it seems to stand second only to climate in its *influence* upon man's activities."—p. 42. "Factors which *limit* the distribution of the more complex forms of manufacture."—p. 212.

Von Engeln (22) writes, "The *dominance of environmental control* has not been generally accepted as an adequate foundation for a complete theory of history." "The book is written not so much to show that human organization and development *have been determined* by geographic conditions as to insist that in future they *should* be." Smith (2), p. 4, tells us, "To an extent little appreciated the environment *makes* the race. It is a common mistake of the historian to give the idea that people have certain qualities inherently. It is much more correct to say that primitive or savage peoples are primitive or savage because of the niggardliness or peculiarities of nature's gifts. The environment . . . has given the qualities." But the strongest statement of control, the best example to date is the testimony of a lecturer on problems arising from the great war. He said, "but Germany *had* to do it, her geography *impelled* her! It was necessity! necessity!! necessity!!!" This was not said in any heated debate or flight of oratory, but in a quiet conversation in my laboratory while maps were being selected for his use.

Bowman (23), p. 3, gives a suggestion on this point of *control.* "Thus plants are thought to have a certain physiologic plasticity or power of self-regulation that tends to adjust them to a new environment, a feature that goes far in explaining the *absence* of *rigid control* of physiographic conditions over forest distributions, although an *approximate control* is often manifested." And Von Engeln (22), p. VI, finds a something somewhat akin in man. "History in sum is the record of man endowed with a free will, refusing at first to conform to his environment and hence being buffeted about by nature until he comes to terms with her."

Jones and Whittlesey (1), p. 4, "Man may make and does make a choice as to how his economic life is ordered." p. 3, "Such knowledge (geographic) is inherently interesting. It is also essential if wise use is to be made of the natural possibilities of any given area." And Febvre (3) adds, pp. 76–77, "Geographers are now striving to bring into prominence the initiative and mobility of man. They regard the land as 'powerful agents,' " but as Newbigin (14) in her preface says, the new

geography methods are by some considered objectionable "in that they take too little account of human intelligence and ingenuity, of man's powers to modify his environment and of evading what is sometimes loosely called *geographical control.*"

Peattie (6) adds, p. 4, "Changing environment is not so important as the changing state of the culture of people," "The varying effects are not so much the result of the changing of the tools which make the impression as of alterations in the human material upon which the tools place their mark. Peoples react differently to the same influences during different stages of their culture or civilization;" p. 6, "We must study human phenomena as we study a body in motion." Brunhes calls it the "principle of activity." Neither do men always "choose the most favorable climate in which to live."—p. 11.

If one says, "The same conditions have the same results," one must remember that conditions include the human mind and its power both of choice and of adjustment.

Jones and Bryan (18), p. 3, state it thus: "We must finally see man gaining a wider freedom through a fuller knowledge;" and Miller and Parkins (15), p. 31, meet Smith above with the suggestion that "Not all racial stocks produce the same results in the same or similar environment." People and countries have grown up together and modified each other until 'stock' means something. And further, p. 33, "Adjustments are not permanent but changing. Absolutely permanent adjustments will never occur with a progressive people."

METHODS OF EXPRESSING RELATIONS.

If we fall into troubles then in expressing the interrelations of men and places by using such terms as conditions, controls, and determinants or if the terms relation and influence are insufficient, how can we interpret our data? Suggestions here, too, can be obtained from the literature.

Jones (24) clears himself in his preface, p. V, "A portrayal of the various factors and conditions *influencing* the trade expansion of the several republics;" then "Special attention has been given to the physical factors *favoring* or *discouraging* production and movement of a commodity." The direct statement with a relative clause may be used. p. 32, "Possibilities for commercial expansion in South America are great because . . . (7–8 reasons)." p. 33–4, "Exports are mainly raw industrial materials because . . . (4–5 reasons)." Hunt-

ington and Williams (4), p. 98, "Just as the water has advantages over land for transportation, so have plains an advantage over mountains." These *advantages* are also well worked out in Huntington and Cushing (7), pp. 114–15 and 133–34.

Jefferson (16) uses the term advantageous, too, in discussing relations. Pp. 39–40, he raises the question, what *stimulates* one city rather than another to grow to the million size. He illustrates relations also by "transformations that help each people (French and English) to settle into its environment while *shaping* it to its own peculiar characteristics."—p. 6.

Miller and Parkins (15), p. 5, "As population increases, and it increases most rapidly where economic (geographic) *advantages* associated with the lands are most abundant." Again, p. 31, "peoples' *opportunities* depend upon size of area, resources and competition."

Peattie (6) uses advantage, and benefits in places, but he strings along the facts of physical and human elements with no sort of connecting phrases to suggest the nature of the relationship. His work is largely descriptive; p. 78, "Today colonies with modern sanitation can maintain healthful conditions in most places in tropical forests. The well organized permanent settlement has little to fear."

Rocheleau (25) finds a few words in which to express the relationships among which are "*causes*," p. 1, "*make necessary*," p. 4, "*disadvantages*," p. 153, but his ontography is about all he has. He speeds on in an interesting way with facts of human occupation, production, building and commerce with rarely a word of explanation, though he recognizes in his opening pages that there are geographical reasons for differences in population densities and in the supply of things to meet man's needs. It is unfortunate to call such a book 'Geography.' Fairbanks (12) is superior in that it has many facts of both environment and ontography, but it does not make many direct statements of relationship.

Two terms, *adjustment* and *adaptation*, are used some. They may be applied either to man himself or to his processes. The words are used in a similar technical sense by Spalding (26) in his admirable study of two phases of plant geography. "Adaptations to the environment are structural, adjustments are physiological."—p. 140. The plants have made many changes in these two categories to meet the conditions in which they find themselves. Vidal Blache (20), p. 9, quotes Haeckel

as follows: Ecology is the science of "*correlations* between all organisms living together, and their *adaptations* to their surroundings." Since Ecology is plant or animal geography these words have good standing and may well be used in expressing relationships in human geography. To be sure a figurative meaning will be necessary in many cases, though of course they can be used of men exactly as of plants in a limited way.

Peattie (6), p. 13, says, "men learn to adapt themselves to new climates;" and of the English soldier in India, "Here the most careful and clever *adaptation* to climatic environment has taken place;" "the reduction of (alcoholic) drinking is another example of adaptation." Men become physiologically *adjusted* to high altitudes and rare air through generations of living in the high plateaus of Bolivia and Tibet. Smith (9) p. 5, "Politics are largely the attempts of men to *adjust* themselves to industrial and economic factors." Perhaps *adapt* would be the better word here.

While man is adapting and adjusting to the conditions in which he finds himself he is also modifying the conditions. Brunhes' statement of this relationship has been quoted. Woeikof (27) says, "man has control chiefly over movable bodies, particularly the mantle rock, or in places where the mantle is thick. He not only changes the inorganic but the organic." Man's modification of conditions is very striking in his health and sanitation changes in low latitudes and in his modification of the water supply and distribution in arid lands. The term is often used by Marsh (28) even in his title, "The Earth as *modified* by man." A different use of the term is found in Huntington and Cushing (7), p. 11, where we read, "Every religion is *modified* by its surroundings, especially those of its birthplace." 'Colored' would be a much better word here for the relation. Their word would apply to changes made in a religion and its terminology when it is transferred from one kind of a place to another.

This part of the paper would not be complete without special reference to a characteristic of geographic interpretation found in some books—the use of words which qualify the influence, relation or response. Every shade of meaning and degree of response may be found. On two or three pages of Huntington and Cushing (7) the following phrases are found: "Man *responds* to geographic surroundings," "Local circum-

stances *alter* man's *responses* to his higher needs," "Europe's *fortunate* size," "North America *hampered* by size and relief," "*Difficulties* of the farmer in rugged regions," "Seasonal variations *hinder* the use of water power."

Miss Semple (29) uses this list of terms and phrases expressive of geographic relationships all on one page. The Upheaved Carpathian Mountains *divided*, *diverted*, *guided*, *checked*. The Alps *retarded*, *delayed*, *obstructed; admitted* invaders, who arrived with *weakened* power, *prolonged the life* of the empire, *facilitated*. River worn valleys *led* to passes, by which traders *crossed*. Today *going* is *easier*, but Alps *collect* toll in higher freight rates, and more coal consumed. Formerly these mountains *barred* the weak and timid. Today they *bar* the poor, and *forbid* transit to all merchandise that cannot pay. Rockies *excluded* all but the strong-limbed and strong-hearted, today *exclude* coal and iron of Colorado from California and *check* the movement of laborers to California, thus *tighten the grip* of labor unions on Pacific coast industries.

Further on, p. 189, large area *misleads* primitive folk, *offers* to advanced people *freest* conditions for their development. A wide territory . . . *affords* most *favorable* conditions. Numerical growth was *rapid*, both by natural increase *reflecting* abundant food, and by accessions *attracted* from the home countries. These examples suggest ways for the careful, thoughtful student to express the relationship without repetition, and with description enough of the relation that the reader can catch its nature.

STRENGTH OF MAN'S ATTACHMENT TO ENVIRONMENT.

On several occasions students have watched the progress of men in their freeing of themselves from the restrictions of environment and have wondered if man would not soon become wholly independent of it. When man overcomes latitude and survives a long, cold journey to the pole by sledge, then boat, dirigible and speedy plane, what more cares he for cold and distance? When he climbs to the top of Mount Everest, what limits do altitude put upon him? When he builds a Panama canal and maintains it with a better health and efficiency schedule than in many parts of the temperate zone, why say he is hampered by the tropics? Isn't he really loosening up all his relations to the environment and even shaking them off?

Perhaps to answer one should go far back in man's history and see how closely he was then related, before coming to final conclusions. Newbigin (14) points out, p. 5, that "in attempting interpretation of past events and historical developments in order to establish correlations between physical and human elements as of ancient dates, there should be a full knowledge of both the conditions and the development." Peattie (6) cautions, p. 10, against broad generalizations and interpretations that go far back where man cannot know. He cites such examples as the effort to explain the sunken neck and high shoulders of the Central Asiatics, the narrow eye slits of the desert people, the dark skins of many peoples within the tropics. It is probably true that we know too little about geographic relations among early races to really answer the question by such comparisons.

May there not be another avenue of approach? Examine Peary or Byrd in his home environment to find what relations he holds to the environment, then examine again on his polar journey and see if he has less relations or more. Note how long he studied and experimented to make enough connections and harmonies, adjustments and modifications to be able to complete his journey.

Count up the relations and contacts with environment that a man in Ohio makes to be able to work in good health, and then note what a wide range of connections and relations the Canal Zone worker has. Not only does he eat and drink, sleep and work there under all the local conditions, but he meets disease with science and medicine brought from elsewhere, reads and thinks in a foreign language and with a foreign outlook, draws a large percent of his food and equipment from distant lands, mines, mills and farms, and even obtains his job and pay from the profits of enterprises thousands of miles away.

It seems probable that every successful man in the temperate zone has closer relations, adjustments and harmonies with his environment than the less successful. The same is true of the nation. If it is true of men in the temperate zone it is to be more and more true of the successful colonizer of the intertropic and polar zones.

Before men could fly, their relations with the air were very limited and their knowledge of it was more restricted. Man surely is establishing closer relations with his environment

in his industry, commerce and trade, science, medicine, agriculture, mining and probably every other occupation. Conquests of oceans, lands, air and life continually add to man's relationships. Not until we know all about the earth, air, sky and life will we cease to extend our relationships to our environment.

SUMMARY AND CONCLUSIONS.

While in many general statements it is quite necessary or, to say the least, very convenient to use such undistributed terms as *influence* and *relation* in Geography, it is very desirable to use terms expressing accurately and clearly the nature of the relationship or influence. Such terms should make it clear to the reader that the *relation* is helpful or detrimental, advantageous or otherwise, and further the degree and kind of advantage can usually be stated. The terms control and demand probably should but rarely be used of geographic factors, but in every case geographers can further the cause by using such terms as really convey the quality, nature and extent of the influence.

It is well to recognize the larger and closer contacts man makes with his geographic conditions as he learns the laws operating in his surroundings. Complete knowledge of all geographic conditions, and of all laws governing all conditions, followed by complete adjustment of every man and occupation to every element of these conditions wherever man makes a contact, would put the individual and the race in a most happy and prosperous harmony, and would insure that humanity was making the best use of all parts of the earth.

BIBLIOGRAPHY.

1. **Jones, W. D.** and **Whittlesey, D. S.** Introduction to Economic Geography, Vol. 1, p. 5. 1925.
2. **Smith, J. Russell.** Industrial and Commercial Geography, p. V. 1925.
3. **Febvre, Lucien.** A Geographical Introduction to History, p. 12. 1925.
4. **Huntington, E.** and **Williams, F. C.** Business Geography, Preface, p. III. 1922.
5. **Johnson, D. W.** Topography and Strategy in the War. Preface, p. IV. 1917.
6. **Peattie, Roderick.** College Geography, p. 3. 1926.
7. **Huntington, E.** and **Cushing, S. W.** Principles of Human Geography, Chapter 1, pp. 1–22. 1924.
8. **Davis, W. M.** Geographical Essays No. 1. Content of Geography. 1909.
9. **Smith, J. Russell.** North America, p. 4. 1925.
10. **Ridgley, D. C.** Geographic Principles. 1925.
11. **Cooley, Chas. H.** Theory of Transportation, p. 91. 1894.
12. **Fairbanks, Harold W.** Europe, Preface, p. VI. 1925.
13. **Newbigin, Marion.** Modern Geography, p. 219. 1911.

14. **Newbigin, Marion.** The Mediterranean Lands, Preface. 1924.
15. **Miller, G. J.** and **Parkins, A. E.** North America. 1928.
16. **Jefferson, M. S. W.** Man in Europe, p. 6. 1926.
17. **Brunhes, Jean.** Human Geography, p. XI. 1920.
18. **Jones, L. C. R.** and **Bryan, P. W.** North America. 1925.
19. **Unstead, J. V.** and **Taylor, E. G. R.** General Regional Geography for Students. 1921.
20. **Vidal, de la Blache.** Principles of Human Geography. 1926.
21. **Brunhes, J.** La Geographie Humaine. 1918.
22. **Von Engeln, O. D.** Inheriting the Earth, Preface, p. V. 1922.
23. **Bowman, Isaiah.** Forest Physiography. 1911.
24. **Jones, Clarence F.** Commerce of South America. 1928.
25. **Rocheleau, W. F.** The Geography of Commerce and Industry. 1905.
26. **Spalding, V. M.** Distribution and Movements of Desert Plants. Carnegie Institution Pub. 113, Washington. 1909.
27. **Woeikoff, A.** Annales de Geographie, Vol. X (1921), p. 98.
28. **Marsh, G. P.** The Earth as Modified by Man. 1877.
29. **Semple, Ellen C.** Influences of Geographic Environment. 1911.

Discussion

Miss E. C. Semple made the valued point that environments are of many kinds and belong to many relams, while geographic conditions are always in the field of the geographer. Hence it is more exact and less cumbersome to speak of geographic facts and conditions than to use the longer more general term environmental factors or elements.

CALCIFIED WOOD FOUND IN UPLAND SAND NEAR CINCINNATI.*

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INTRODUCTION.

The specimens of calcified wood here reported are of interest for three reasons. Because of the pronounced crystallization habit of calcite, cell structure is usually obliterated by the crystal growth. For this reason, the replacement of wood structure by calcite has seldom been reported.[1], [2]. A case of partial replacement of wood by dolomite is reported by S. F. Adams.[3] In the petrified wood here noted, the wood structure is imperfectly preserved and fragmentary, but sufficiently clear for identification as a gymnosperm.

Another point of interest is the probable age of the wood. The sand in which it is found may be of late Tertiary age as inferred by Dr. Leverett,[4] but it seems more likely to be of pre-Illinoian Pleistocene age. Calcified wood as recent as the Pleistocene has not been reported, as far as known to the writer.

In addition, the position of the water-laid sand is interesting. It occurs on the upland a mile and a half south of the Ohio River and a mile and a half west of the valley rim of the Licking River at an elevation of 390′ to 400′ above the present water level.

PHYSICAL CHARACTER OF WOOD FRAGMENTS.

The wood specimens are of two sizes. The smaller pieces are 3 or 4 inches long and about one inch in diameter (Fig. 1), and the larger are 8 to 12 inches long and 4 to 6 inches in diameter. (Fig. 2). The smaller are calcified throughout with a brown limonite stain along the annual rings and on the outside surface, which resembles bark. The wood fragments

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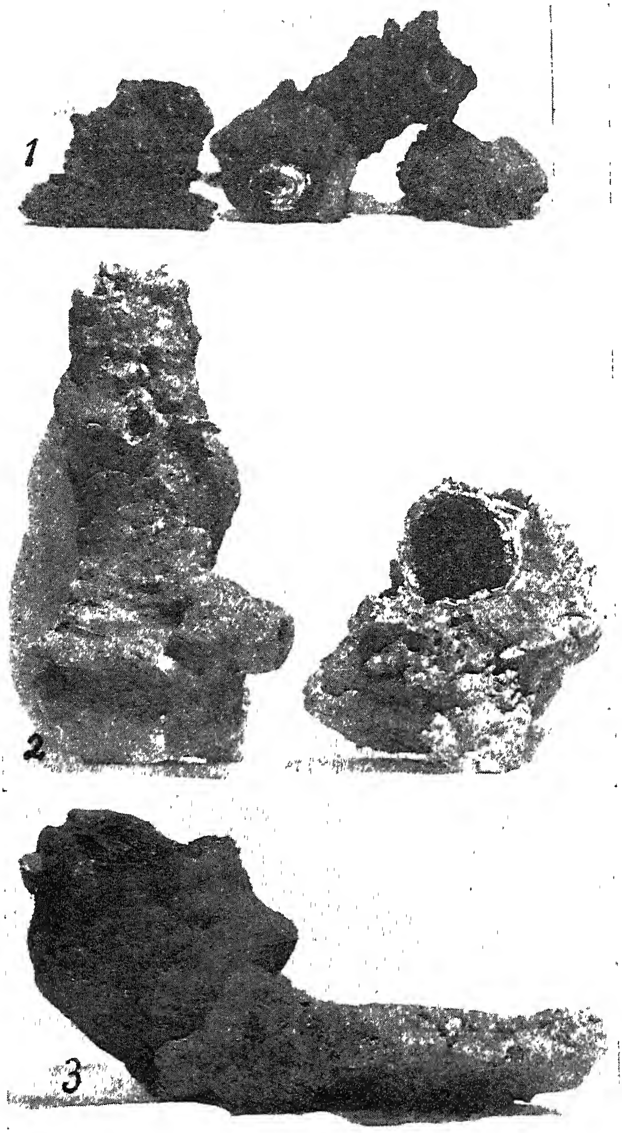
[1]Greenland, C. W., Economic Geology, Vol. 13, 1918.

[2]Wherry, E. T., Proc. U. S. National Museum, Vol. 53, June, 1917.

[3]Adams, S. F., Journal of Geology, Vol. 28, 1920.

[4]Leverett, Frank, Kentucky Geological Survey, Series VI, Vol. 31.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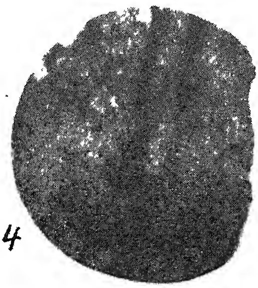
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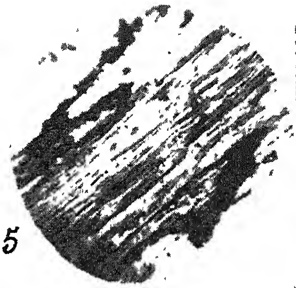
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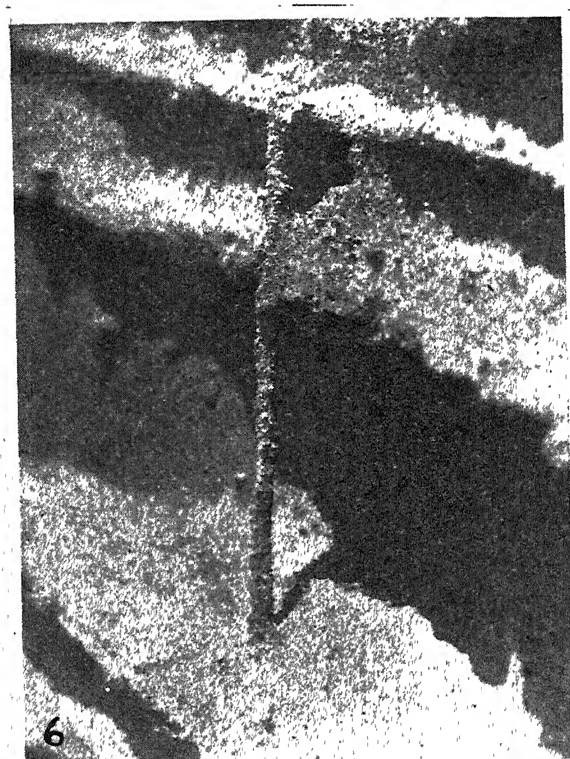
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are in part hidden by cemented sand clinging in concretionary form. The smaller specimens occur in generally horizontal position projecting from the deposit. The larger pieces are merely shells of limonite with the central portion missing altogether except where broken-off branches project, and these are filled with calcite.

The large shells appear to stand in upright position, and one which had been thrown aside by the workmen and was not seen in place, stands at right angles to a flat, cemented layer which one would expect to be approximately horizontal. (Fig. 3).

There is no cell structure preserved in the larger specimens, so they are of interest chiefly because the relative position of the two kinds of fossils suggests that the smaller are branches of the larger, especially since the latter have broken branches of about the same cross section as the small pieces. The fossilization in the smaller specimens is so imperfect that it cannot be said whether we are dealing with stems or roots. It seems unlikely that they are modern roots which have penetrated from the present surface which is 12 or 15 feet above and separated from the sand by a heavy layer of calcareous and limonitic cement.

MICROSCOPIC CHARACTERS.

From what seemed the best specimen of wood, fourteen thin sections have been made for examination under the microscope. These include five cross-sections, five tangential sections, and four radial sections. The cell structure as exhibited in the cross sections is very imperfect, but seems to show (Fig. 4) that the wood is without the pores or vessels which all angiosperms show. This would identify the wood as that of a gymnosperm. In radial section the tracheids are not clear enough to make certain whether the pits are bordered as in all gymnosperms or not. In tangential section the ends of the medullary rays are clear in several cases and these are undoubtedly uniseriate (Fig. 5) which is characteristic of many gymnosperms, though not diagnostic.

Closer than this, the identification seems impossible from the sections at hand. Before the specimen was ground, both Dr. Walter Bucher, of the Geology Department of the University of Cincinnati, and Dr. John Hoskins, of the Botany Depart-

ment, thought the general appearance of the wood was like that of a cedar. Nothing in the microscopic examination is contrary to this, though a definite identification is not possible.

DEPOSIT IN WHICH THE WOOD WAS FOUND.

The fragments of wood were found in an 8- to 10-foot deposit of very fine sand on the upland a little more than one mile south of Covington, Kentucky at an elevation of approximately 820′ A. T. The sand is very fine with scattered tiny chert pebbles, partly cross-bedded, with bedding planes outlined in brown, and very calcareous throughout. In this fine material occur abundant concretions of random shapes and enormous proportions, in addition to the many specimens of calcified wood, themselves forming nucleii of concretions. The sand is being removed for sale as molder's sand in aluminum and brass work, its per cent of calcium carbonate being too high for use in molding iron.

At the top of the bed of sand is a cemented zone 8 to 10 inches thick which is largely calcium carbonate, but also partly limonite. In some places, the cement is quite solid throughout and in places it is made up of fragmentary beds separated by unconsolidated material. These consolidated layers separate the lower deposit from a succession of coarser water-laid beds above, in places calcareous and in places leached, which appear to be composed of succeeding layers of greatly decomposed gravels and clean sand, with one thin band of bowlder clay. The reason for the band of cemented material seems clear from the fact that the sand below grades into a foot or more of the finest silt toward the top, immediately beneath the present zone of cementation. This is followed above by the coarser, pebbly sand and gravel. When the deposit was first excavated there appeared in the gravel one band of bowlder clay about six inches thick with ten or fifteen feet exposed laterally. In the absence of any other bowlder clay in any other exposure in the neighborhood, the band of ice-laid material was interpreted as due to a floated ice block. This has been supported by the entire disappearance of the band of till since the excavation has been cut farther back, and by its failure to appear in a new excavation in the same deposit at a little distance from the first digging.

DEPOSIT OF DECOMPOSED GRAVEL.

At a higher level, up to 900′, but apparently continuous with this deposit, is a greatly decomposed gravel, dark brown and streaked with black stains, which is leached to a depth of 18 to 20 feet so that it does not effervesce with weak hydrochloric acid. This deposit has abundant pebbles up to three inches in diameter, though mostly small, and many are so decomposed that they crumble to powder in one's fingers. The pebbles are largely of chert and quartz, though many of quartzite, granite, gneiss and basalt were also found. It is the granite and gneiss pebbles which are so greatly decomposed and these give off strongly the odor of kaolin. The pebbles lie in a matrix of clayey material, the result, probably, of their own decomposition and not like bowlder clay. Besides, there are no bowlders. The material is decomposed gravel, not bowlder clay. The deposit is being cut away and screened, for use as molder's sand in molding iron. This deposit seems to correlate with an exposure at the same level on the Dixie Highway about half a mile distant and three quarters of a mile northeast of Ft. Mitchell. Here the material is largely sand showing horizontal bedding planes.

From the top of the leached gravel to the base of the sand in which the calcified wood was found, there is a difference in elevation of 75 feet as measured with the aneroid, and the two kinds of material appear to be a continuous deposit down the slope of the hill. The sand is said to rest on clay below, but this is not exposed.

PRE-GLACIAL EROSION SURFACES.

Glacial sand and gravel on the upland 390′ to 465′ or 470′ above the present drainage (Licking River at 430′ two miles east, Ohio River at 430′ one and a half miles northwest) points, of course, to a time in the Pleistocene when the drainage of the region was at that level. It is believed, however, that the level on which the deposit now rests was at the time of deposition at a lower altitude. That there are high-level benches in this vicinity representing old valley floors antedating the present rejuvenated streams will be discussed in a later paper. Of these, the old 800′–820′ erosin surface, the highest of such benches in this vicinity, is represented by prominent shoulders, clearly to be seen in the field. The ridge southwest of Covington

has on both sides ridge-like shoulders extending out toward the valleys, which are remnants of this old bench along the old drainage lines. These fragments of the same level present on the map the characteristic pattern of a dissected terrace. The sand where the wood was found rests on one of these shoulders.

The 800′–820′ valley floor is succeeded at about 700′–720′ by another level which also extends tongues of land out toward the valleys, less prominently in this exact location than elsewhere in the Cincinnati quadrangles. There are reasons for believing that both these benches probably existed above the drainage in early Pleistocene time, but that the present trenching of the rivers has taken place since, as stated by Dr. Leverett.[5] Such benches, if they did exist, would be apt to receive and hold a river-laid deposit at any time of unusual flooding.

AGE AND ORIGIN OF DEPOSITS.

To review the evidence for reconstructing the history: The sand where the wood fragments were found is very fine, grading into a powdery silt at the top and it has no pebbles except tiny ones of chert. This is separated from the gravel and sand above by the zone of calcareous cement. The gravel is without any doubt of glacial origin. The events interpreted from these facts might well have been as follows: As the ice from the north advanced, the Licking, or some other north-flowing stream of this region, was dammed, causing it to deposit sand followed by silt as the current slackened to none at all. This was followed by an invasion of outwash from the ice front. If the upright position of the tree trunks be more than accidental, they may have been buried in place as the flooding waters encroached on the higher levels. The outwash material at 900′ marks the relative level to which the glacial waters rose.

If this break in the kind of material at the cemented layers can be interpreted as given above, the sand and the included calcified wood would be of Pleistocene age. The glacial material above the river sand and clay would have furnished the lime for the cement which has been localized by the contact with silt, as well as for the concretions and the calcified wood.

As to the age more exactly. The upper deposit of decomposed gravel—not immediately in contact with the sand and silt—but higher up the slope (880′–900′), as mentioned above,

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[5]Leverett, Frank, loc. cit.

is leached to a depth of 18 to 20 feet, whereas gravel of Illinoian age exposed at the surface at Mariemont just north of the Ohio River is leached only 8 to 10 feet below the surface. This would seem to signify that the age of the gravel is pre-Illinoian as given by Dr. Leverett.[6] Dr. Leverett, however, speaks of the material on this ridge as drift and till. Only one narrow band of till, later removed by excavation, has been seen by the writer. The whole ridge as far as exposures furnish data would seem to be covered with outwash of a pre-Illinoian glacier rather than by till.

OTHER CALCIFICATIONS IN PLEISTOCENE SAND.

In Cincinnati in a valley deposit of accepted Illinoian age, shells of two tree trunks or large branches were found at the level of a cemented zone between outwash below and bowlder clay above. These were in appearance like the larger specimens found in Kentucky and seem to the eye unlikely to show any cell structure under the microscope. Their position was horizontal. The exposure is on Este Avenue just north of Ivorydale.

Another mode of calcification was observed in the same deposit in very fine sand at a place where the zone of cement was missing between the sand below and bowlder clay above. Rootlets, evidently modern, had penetrated from the surface and when exposed in the excavation for sand showed a white encrustation of lime. (Fig. 6). Also fault planes, evidently due to slumping when the very fine sand was wet, were accentuated by planes of calcareous deposit projecting slightly beyond the steep slope of sand. Many rootlets had also taken advantage of the space along the fault planes and these, too, were encrusted with lime. So calcification of a sort seems to require no great length of time.

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[6]Leverett, Frank, loc. cit.

MICROFOSSILS IN AN ARKANSAS PEAT AND THEIR SIGNIFICANCE.*

PAUL B. SEARS AND GLENN C. COUCH.

OBJECT OF THE INVESTIGATION.

This is an extension of a series of studies by one of the authors and his associates (1) on fossil pollen in peats of the North Central States. The purpose of such studies has been to secure information concerning the general trend of climate in postglacial time, as an aid in interpreting present vegetation.

These previous studies have indicated that postglacial climate has been largely of continental type, cool at first and later warm. Separating the cool dry from the warm dry period there appears to have been a definite although brief period of greater humidity, relative if not absolute. A similar increase of humidity is believed to have occurred recently.

In the present study diatom remains, as well as pollen, have been considered. This was necessitated by the destruction of all carbonaceous matter in the upper layers by the fire which led to the discovery of the deposit.

The recent character of the deposit permits a study of the latter portion only of postglacial climate, but the results so far as they go, are consistent with those obtained elsewhere. We estimate the record to extend back at least 1800 years—basing this figure on the age of cypress stumps and a conventional figure of three centuries per foot of peat. This estimate seems quite conservative.

MATERIAL.

Dark Hollow is a former lake bed at the northern edge of the Arkansas River terrace, 1 mile northeast of North Little Rock, Arkansas. The area is now drained by a large ditch and under cultivation, but its former character is shown by huge cypress logs. One stump still in position has a diameter of 4–5 feet above the buttresses. The existence of peat here was revealed by a subterranean fire early in 1931. The State Geological Survey thereupon sent specimens of this peat to

*Contribution from the Botanical Laboratory, Univ. of Oklahoma, NS No. 14.

Professor Albert W. Giles to whom the writer is indebted for knowledge of the deposit.

Collections were made in March, 1931, after the fire had ceased. The peat was then overlain by about eighteen inches of ash and slag and was itself so hard that the use of a borer was impracticable. Specimens were secured by cutting back steps at the edge of the machine-made ditch. About four feet of peat lay below the ash, all very clayey. This clay increased in stiffness downward until a layer of heavy blue clay without fossils was reached. Samples were taken at intervals of six inches.

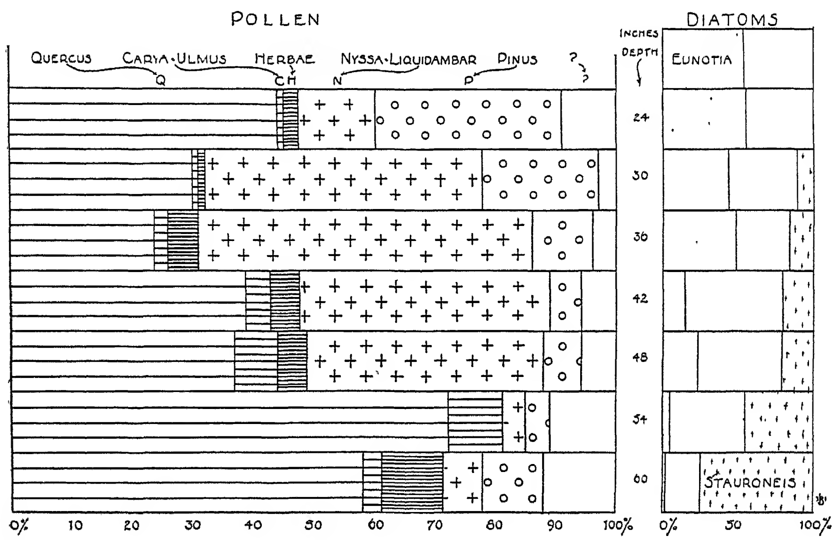

FIG. 1. Diagram showing changing percentages of fossil pollen and of fossil diatoms at successive depths in Dark Hollow peat near Little Rock, Arkansas.

PROCEDURE AND RESULTS.

To permit study of diatoms, slides were prepared by nitric acid treatment in addition to those prepared with KOH for pollen study. Samples were centrifuged and mounted in glycerine jelly as in preceding studies (2). Slides were prepared by Miss Mabel Larcomb who also assisted with the pollen counts. All diatom counts were made by the second author.

The results, expressed as percentages, are given in Tables I and II, and summarized graphically in Fig. 1. Pollen of *Quercus* predominates up to the 48″ level. The 48″ to 30″ levels inclusive show a strong admixture of *Nyssa* pollen.

Pinus forms less than 10% of the whole until the 30″ level is reached, from there on increasing rapidly toward the top where with oak it is relatively abundant. Herbs (amaranths, composites, grasses) are most abundant at 60″. *Carya*, while never abundant is most nearly so at the 54″ level. Pollen

TABLE I.

PERCENTAGES OF FOSSIL POLLEN IN DARK HOLLOW (ARK.) PEAT.

Depth in Inches	Amaranthus, etc.	Carya	Compositae	Gramineae	Liquadambar	Nyssa	Pinus	Quercus	Ulmus	Unknown	Pollen Frequency
24 .	. .	01	03	. . . .	.01	.11	.31	44	. . . . .	.09	277
30.	. . . .	01	01	. . . .	02	.44	.19	30	. . . .	.03	645
36 .	. . .	.01	05	. . .	04	.51	.10	24	.01	04	231
42 . .	.	04	05	. . .	01	40	.05	39	. . . . .	.06	49
48.	01	.05	04	. . .	06	33	06	.37	.02	06	93
54	.	.09	. .	. .	.04	. . .	04	.72	. .	11	62
60 . . .	.01	.03	.06	03	. .	.07	.10	.58	. .	.12	16

frequency (PF) decreases from values above 250 per sq. cm. of slide at the top to 16 at the 60″ level. In the blue clay below that level both diatoms and pollen are absent or exceedingly rare.

TABLE II.

PERCENTAGES OF FOSSIL DIATOMS IN DARK HOLLOW (ARK.) PEAT.

Depth in Inches	Eunotia sp.	Melosira varians	Pinnularia lignitica	Nitzchia sp.	Stauroneis sp.	Pinnularia nobilis	Eunotia robusta	Cymbella sp.	Navicula amphiloba	Pinnularia major
18.	54	.17	.05	05	. . . . .	.04	. . . .	. . . .	. . . .	.26
24.	.55	. . . .	.09	.25	. . .	. . . . .	.	. . . .	. . . . .	.12
30.	43	07	.07	. . . .	.11	. . . . . .	.05	.08	07	.11
36	.48	.05	02	. . .	.16	. . . . .	. . . . . .	.01	.09	.19
42	.14	. . . . .	02	.04	.20	.06	. . . . . .	.04	04	.45
48	.23	.04	.09	.04	.21	.06	. . . . .	.03	. . . . .	.29
54	05	. . . . .	. . . . . .	. . . .	.45	.36	05	05	. .	05
60	.01	. . . .	03	. . .	.76	.01	. . . .	. . . .	. . . . . .	.18

No pollen of *Taxodium* was certainly identified, although the area has been evidently occupied by cypress for at least 800 or 1000 years. This agrees with the experience of Lewis and Cocke (3) in the study of the Dismal Swamp, and illustrates one of the sources of difficulty in pollen analysis.

Among the diatoms *Eunotia* sp. shows a striking increase toward the top while *Stauroneis* sp. shows an equally striking decrease from the bottom upward. *Pinnularia major* appears in fluctuating percentages throughout, while *Nitschia* and *Melosira* are more abundant toward the top.

INTERPRETATION OF RESULTS.

There is good reason to believe that the upper 18″ of burned material represents peat essentially like that in the 24″ layer. Not only the general similarity of diatoms is evidence of this, but also the fact that the 24″ layer consists largely of pine and oak—the characteristic vegetation of the region at present. Air dry peat from the 24″ level when burned in an electric muffle shows a linear shrinkage of 20% indicating that the 18″ of ash represents at least 22″ of original peat. Settling to a depth of several inches has occurred over the burned area.

The task of climatic interpretation would of course be greatly simplified if specific instead of generic distinctions cf pollen could be made. Such distinctions will be possible when our knowledge of pollen taxonomy is extended and refined (4) and have already been employed in certain cases (5) (6) (7). But their use in any case will involve an enormous increase of labor, not justifiable as a practical measure until other means have been utilized so far as possible.

The very low pollen frequency just above the clay, together with the abundance of black humified globules suggests that the lower part of this peat was deposited under conditions so dry or so exposed that extensive oxidation occurred. The steady increase of pollen frequency upward might be due to a number of causes, but is at least not inconsistent with other evidence indicating a corresponding increase in climate humidity.

The most striking feature of the pollen profile is the small number of genera involved. *Juglans*, *Acer*, *Fagus*, *Fraxinus*, all of which preserve well and are characteristic of the more humid hardwood forest east of Arkansas are here missing. This suggests that no part of the column represents deposit from an adjacent vegetation any richer than that of the present in Arkansas. On the other hand if one goes west from Arkansas today the predominant upland forest of *Pinus echinata*, *P. taeda*, *Quercus* sp., *Carya glabra et* sp. gives wey to one in which the pines are absent and oaks, notably *Q. marylandica* and *Q. stellata*, with some *Carya*, are dominant. The Dark Hollow

pollen profile exhibits just such a change from top to bottom. This warrants the inference that the 60″ and 54″ strata were deposited under climatic conditions approaching those of central or eastern Oklahoma, i.e. notably drier than the present climate of Central Arkansas, and that the upper strata accumulated under conditions of increasing humidity.

Nyssa, so conspicuous above the oak and below the oak-pine strata is prominent today in both the upland and swamp vegetation of Arkansas and eastern Oklahoma, but does not appear in abundance so far west as do the oaks. Whether its prominence at intermediate levels indicates an increase in swamp areas or an enrichment of the upland vegetation, or both, cannot be determined. In either case the indications favor a recent increase in climatic humidity consistent with the idea of the preceding paragraph.

Thornthwaite (8) in his studies of climates and soil types in Oklahoma has observed that present climatic boundaries do not correspond with the appropriate soil limits, but lie west of them. This too is quite consistent with our evidence of a recent increase in humidity, for the effect of climate on soil requires time to register.

Finally it is interesting and possibly significant to note that the diatom *Stauroneis*, so prominent at the base of the profile, is today abundant in central Oklahoma while *Eunotia* is rare there but abundant eastward. However, this statement is based on a limited number of collections.

SUMMARY AND CONCLUSIONS.

The circumstances just discussed, to-wit: the succession from an impoverished oak-hickory fossil flora of low pollen frequency through a considerable *Nyssa* stage to an oak-southern-pine fossil flora of high pollen frequency, with a corresponding shift from *Stauroneis* to *Eunotia* in the diatom fossils are interpreted as indicating a recent increase in climatic humidity for central Arkansas. This agrees with earlier findings in the North Central States, and is of interest because the Dark Hollow peat lies far south of the glacial boundary.

REFERENCES.

1. Sears, P. B. Postglacial climate in eastern North America. Ecology (in press).
2. ———Pollen analysis of Mud Lake Bog in Ohio. Ecology, 12, 4: 650-655. 1931.

3. **Lewis, I. F.** and **Cocke, E. C.** Pollen Analysis of the Dismal Swamp peat. Journ. Elisha Mitchell Soc. 45: 37–58. 1929.
4. **Wodehouse, R. P.** Personal communication. 1931.
5. **Sears, P. B.** A record of postglacial climate in Northern Ohio. Ohio Journal of Science, 30, 4: 213. 1930.
6. **Furrer, E.** Pollenanalytische Studien in der Schweiz. Beibl. Viertelj. Naturf. Ges. in Zürich. 72, 14. 1–38. 1927.
7. **Hormann, H.** Die pollenanalytische Unterscheidung von *Pinus montana*. *P. sylvestris* und *P. cembra*. Oesterr bot. Zeitschr. 78: 215-228. 1929.
8. **Thornthwaite, C. W.** Personal communication. 1931.

NOTES AND COMMENT.

It will be noticed by reference to the inside page of front cover that the editorial staff has been reorganized and augmented and that a wider distribution throughout the state is provided for. The cordial co-operation promised by members of the staff will, we feel sure, result in a greater range of selection for articles and, we trust, for a greater usefulness to science workers generally.

H. O.

NOTICE.

IMPORTANT TO MEMBERS OF THE OHIO ACADEMY OF SCIENCE.

Under the action taken by the Academy at Oxford, last April, it is necessary that all nominations to fellowship in the Academy must be in the hands of the Secretary at least 60 days before the annual meeting at which they are to be voted on. If, as has been the custom the past several years, the annual meeting is held near Easter, which comes next year on March 27, the nominations must be filed in January. A suitable form on which to make nominations can be secured from the Secretary.

The Executive Committee of the Ohio Academy of Science has authorized, subject of course to ratification by the Academy, the formation of a new section, a *Section of Geography*, with Dr. Eugene Van Cleef, of the Geography Department, Ohio State University, as the temporary Vice President. Persons interested in this section should communicate with Doctor Van Cleef.

W. H. ALEXANDER, *Secretary*.

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AN UNUSUAL OCCURRENCE OF STALACTITES AND STALAGMITES.

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INTRODUCTION.

Since few cases are on record of stalactites and stalagmites growing above ground, under normal atmospheric conditions, it occurred to the writer that a brief paper on the subject might be worth while. During the Summer and Fall of 1931 the author conducted a careful investigation of the rate and mode of growth of stalactites, and obtained some data on stalagmites.

The writer does not assume from the data obtained that one is able to arrive at a definite figure as to the length of time any large stalactite or stalagmite has been growing. As pointed out by Allison[1] and others, there are a number of factors which affect the rate of growth, and one can hardly expect to secure uniformity in results from stalactites and stalagmites growing under diverse conditions. It is interesting to note that the rate of vertical growth of the stalactites, in the early stages of development, compare closely with those of Allison,[2] in spite of the fact that those here cited grew above ground, where evaporation would be more rapid as a result of better circulation of the air, and where the Summer temperatures are higher. One would expect the stalactites of Allison to grow slower because they developed in a mine tunnel, underground, where humidity was high and the summer temperatures lower.

[1]Allison, Vernon C. The Growth of Stalagmites and Stalactites. Journal of Geology, Volume 31, 1923, pp. 106–125.

[2]Idem., p. 111.

CONDITIONS UNDER WHICH THE STALACTITES GREW.

The photograph, Fig. 1, is a view of the steel bridge of the Pennsylvania Railroad, where it crosses Bever Street in the city of Wooster, Ohio. According to railroad officials this bridge was constructed in part in 1908 and the remainder in 1912. It is approximately 200 feet long and 75 feet wide and rises about 20 feet above the paved street. Steel, latticework pillars support a superstructure made of thick, steel plate riveted together in an imperfect fashion to form a series of rectilinear, box-like structures, about a foot wide and about that deep. After the completion of the steel framework, concrete was poured into the boxes or troughs, filling them and covering them with several more inches, making a fairly smooth surface of the whole. On top of this steel and concrete base was laid approximately four feet of crushed limestone which was obtained from quarries located near Dunkirk and Bloomfield in northwestern Ohio. Some of this stone has a comparatively low magnesium content. Mixed with the rock ballast, but in small amount, are the usual cinders and fine coal found along railroad tracks. Due to poor drainage, much of the rain water accumulates in pools and gradually seeps into and through the rock ballast and cracks in the cement and out through the joints between the steel plates. The stalactites hang from the edges of the rectangular boxes where the joints occur, or from the steel girders just below them. More than three hundred were counted, varying from a fraction of an inch to twelve and one-half inches in length. New ones are forming at all times and most of them are in process of growth. After a heavy rain the drip is most active and least during a period of drought and during the cold winter months when the ground is frozen.

It is clear that the conditions here, above ground, are quite different than those in a cave, where the humidity is higher and summer temperatures lower. The temperature underground varies little throughout the year, whereas above ground it varies from as low as 10 degrees below zero in winter to as much as 100 degrees in summer. During this season, when the pavement is hot and automobiles are constantly passing beneath the bridge, the circulation of warm air must necessarily be favorable to rapid evaporation. Underground, stalactites and stalagmites grow all the year round, whereas above ground

in this latitude their growth must vary more or less with the seasons. The conditions are unusually favorable for rapid growth during the summer when evaporation is high, provided the rainfall is normal. Organic acids derived from decaying vegetation and the roots of growing plants are said to aid in dissolving limestone. Here, there is high concentration and no vegetation present; organic acids are therefore of no consequence in this case. The water in its downward journey through the limestone and cement picks up its load; how much is obtained from the limestone and how much from the cement is impossible to determine. The stalactites described by Allison[3] developed as a result of percolation of water through concrete. He arrives at the conclusion that carbonic-acid charged water abstracts limestone more easily from young or green concrete.

ANALYSIS OF THE STALACTITES AND STALAGMITES.

An analysis of the stalactitic and stalagmitic material was made by J. W. Ames, associate in agronomy at the Ohio Experiment Station located at Wooster, Ohio, and is as follows: Calcium Carbonate, 93.88%, Magnesium Carbonate, 1.53%. The total carbonate content is 95%. This signifies that the Calcium and Magnesium are practically all in the form of carbonates. The remaining 5% is Aluminum and small amounts of insoluble material, Silica and Iron. The solution has a bitter taste.

MODE OF GROWTH OF THE STALACTITES.

The stalactites start as slender tubes about 0.4 cm. to 0.5 cm. in diameter at the tip, widening sharply near the base to a diameter varying from 0.8 cm. to 1.5 cm. The walls vary from an extremely thin fragile shell, .2 mm. to .45 mm. in thickness to more than a quarter of an inch in the larger ones. They are all symmetrical, tapering off uniformly to the tip and showing no variations or inequalities in diameter. A great number of specimens, large and small, were measured and found to have diameters at the tip of 0.35 cm. to 0.5 cm., the average being 0.4 cm. It is the diameter of the drop, regardless of the length and diameter of the stalactite, which here controls the diameter of the tube at the tip of the growing stalactite.

[3]Idem., 1.

The writer had adequate opportunity to make a careful study of the development of stalactites in their early stages of growth. A great number of them were studied in all stages of development, from the fragile rim deposited at the periphery of the initial drops, to those twelve and one-half inches long. The manner of growth, from the first drops of solution which hang from the steel girders first commands our attention. The size of the initial drop is determined to a large extent by the nature of the surface from which it hangs. Those measured were found to vary from 0.8 cm. to 1.5 cm. in diameter. The shape and diameter of the initial drop determines the shape and diameter of the base of the initial stalactite. Observation of a number of drops suspended from a flat surface reveals a conical form. The sides curve up concavely from the rounded tip. As the drop grows in size, and becomes more elongated, the sides become more concave. When the weight of water (gravity) becomes greater than the surface tension, a drop falls. As the drop hangs from the surface, it loses water by evaporation, and carbon dioxide as a result of less pressure. Particles of calcium carbonate are precipitated and form a translucent film over the drop. This film breaks if the evaporation is good and the particles go whirling to the rim of the drop, where they become attached to the wall of the growing stalactite. This spinning motion observed in drops on actively growing stalactites is due to surface tension and to the fact, as pointed out by Allison, that the down-flowing current is at the center of the drop and the up-flowing current at the periphery. The first deposition takes place at the periphery of the initial drop, the diameter of which is much greater than the stalactite which develops later. The addition of successive zones of carbonate of lime gives the base of the stalactite a conical shape, like that of the initial drops. The writer examined a number of stalactites in their very earliest stages of growth and found that the conical base takes the shape of the initial drop. In some cases a translucent film forms over the entire drop, enclosing it in a thin delicate shell. These shells all have the shape of the drop; conical with concave sides. They serve to hold the water and have the appearance of large blisters, which when broken are found to be full of water. They are horizontally banded, indicating that their vertical growth was by the addition of calcium carbonate to the rim. An examination of the interior of the delicate, conical shells reveal horizontal

zones of minute, rounded botryoidal excrescences, a form frequently taken by calcium carbonate. These excrescences are also present inside the fragile shell, in zones or bands of growth, at the tip of the growing stalactite. When the drop is "alive" and the stalactite continues to grow, which is usually the case, the tip of the basal cone is open. The constant push of the water from above ruptures the film. The opening at the tip of the cone has the diameter of the drop which is about to fall. The diameter of the stalactite at the tip of the cone is therefore determined by the diameter of the drop at that point. As the stalactite lengthens, its diameter at the tip is constant or nearly so, because the diameter of the tube governs the diameter of the drop. It appears that the drops from all the stalactites are nearly the same diameter, measuring at their tips 0.35 cm. to 0.5 cm. in diameter, the great majority measuring 0.4 cm. This would indicate that surface tension is the controlling force which determines the diameter of the drop. The force would be equal to, or slightly exceeding the weight of the water in the drop. If the force of surface tension were constant, the size of the drop would be the same in each case. This would explain the uniform diameter of the tips of the growing stalactites.

As the stalactite lengthens, its diameter above the tip increases. Successive, concentric rings of growth are added to the exterior of the initial tube. The calcium carbonate is very porous, resembling calcareous tufa. Spaces are present between the rings of growth and openings occur in the walls. The water is held in the tube and spaces by capillarity. The pores allow the water an easy exit to the exterior of the stalactite where evaporation is responsible for additional deposition. Carbonate of lime is also deposited interstitially. In the large stalactites taken from caves, the rings of growth are present but no spaces are present between them. The tubes in the larger ones are closed by carbonate of lime. As the stalactite increases in length and diameter by additions to the exterior, its evaporating surface increases. As a result, much of the carbonate of lime is deposited interstitially and added to the exterior to increase the diameter, and a smaller proportion reaches the tip to increase its length. In this case the spongy, porous, calcareous material holds part of the solution. As a stalactite increases in diameter its vertical growth is slower.

The stalactite tubes are frequently sealed over at the tip by a film of calcium carbonate. This explains why many of them when bisected longitudinally, exhibit tubes subdivided into sections by transverse, rounded partitions, concave upward. After the end is sealed by the film, the water, not able to break it, passes through the walls or flows down the outside of the stalactite and continues to lengthen it.

RATE OF GROWTH OF THE STALACTITES.

On August 8th, 1919, the bridge was given a coat of paint, and the stalactites that had accumulated were removed. Therefore none of the stalactites are older than the above date, more than twelve years ago. It is not known definitely whether any of them started to grow immediately after the bridge was painted, but it is probable that some time elapsed before the water could make its way through the paint which doubtless filled the joints between the steel plates. Many new stalactites have been forming at all times and it is possible that all of them are less than twelve years old. Some that have been observed during the past few years are several inches long. If we assume that the largest stalactite of the group, which measures twelve and one-half inches in length, started to grow immediately after the bridge was painted, the average growth per year would be a little over one inch. If we take an average of twenty-one of the largest stalactites, varying from 8.33 cm. to 31.75 cm., averaging 18.54 cm. in length, on the assumption that they started to grow shortly after the bridge was painted, the rate of increase in length would average for all about 1.72 cm. per year. This figure does not represent the actual increase in length per year, for stalactites increase in length much faster during their early stages of growth. This is to be expected, for as the stalactite increases in size there will be a much larger evaporating surface and a part of the solution evaporates before it reaches the tip.

It was possible to get the rate of growth for this growing season because the portion of the stalactite recently added shows up as a white deposit. The older portion has been colored by dust and grime thrown up by the constant procession of automobiles during the last year. Some of the stalactites of the growing season of 1931 are at least four inches long and the variations in length of the recent additions indicate a great difference in the rate at which they increase in length.

After two months, July and August, 1931, the group of twenty-one stalactites, included in the accompanying table, were measured again to determine what increase in length had taken place. It was found that their increase in length was extremely variable, ranging from .18 cm. to 1.98 cm. Several areas of growing stalactites were removed and in twenty days new ones developed on the site of the old ones. Three of these were .32 cm. long, one .55 cm., two .63 cm., one .72 cm., one .80 cm., one .87 cm. and another 2.14 cm. On October 20,

TABLE I.

Stalactite	Length	Diameter at Base	Diameter at Tip	Rate of Drip
1	8.34 cm.	0.08 cm.	0.4 cm.	One drop in 2 min.
2	18.76 cm.	1.12 cm.	0.4 cm.	" " " 1 min., 22 sec.
3	14.45 cm.	1.18 cm.	0.4 cm.	" " " 15 sec.
4	15.95 cm.	1.04 cm.	0.4 cm.	" " " 16 min., 40 sec.
5	15.40 cm.	1.35 cm.	0.4 cm.	" " " 9 min., 58 sec.
6	17.86 cm.	0.88 cm.	0.48 cm.	" " " 6 min.
7	16.20 cm.	1.18 cm.	0.48 cm.	" " " 7 min., 15 sec.
8.	16.59 cm.	0.88 cm.	0.48 cm.	" " " 9 min., 11 sec.
9	23.66 cm.	1.44 cm.	0.48 cm.	" " " 11 min., 30 sec.
10.	15.24 cm.	1.5 cm.	0.48 cm.	" " " 45 sec.
11.	20.32 cm.	1.12 cm.	0.48 cm.	" " " 1 min., 5 sec.
12.	16.51 cm.	1.27 cm.	0.48 cm.	" " " 15 min.
13.	15.07 cm.	1.04 cm.	0.4 cm.	" " " 24 sec.
14.	16.12 cm.	1.27 cm.	0.48 cm.	" " " 8 min.
15.	17.94 cm.	1.04 cm.	0.48 cm.	" " " 7 min.
16.	17.14 cm.	1.04 cm.	0.4 cm.	" " " 7 min.
17.	20.23 cm.	1.04 cm.	0.48 cm.	" " " 5 min., 15 sec.
18.	20.72 cm.	0.88 cm.	0.48 cm.	" " " 10 min.
19.	23.50 cm.	0.88 cm.	0.4 cm.	" " " 18 min., 35 sec.
20	31.75 cm.	1.12 cm.	0.48 cm.	" " " 30 sec.
21.	23.64 cm.	1.27 cm.	0.48 cm.	" " " 37 sec.

1931, two months after the stalactites were removed, thirteen were measured to obtain their length. The following figures in centimeters shows their growth: 1.7, .9, 1.92, 1.87, 1.37, 1.5, 1.8, .71, 1, 1.76, 1.7, 1.77 and 1.87. The average increase in length per month is .76 cm. which compares favorably with the readings obtained by Allison[4] who reports growths varying from 0.10 cm. to 1.44 cm., averaging for all .71 cm. That the two results are so nearly alike seems remarkable, in view of the fact that the conditions under which both groups were developed are so different. One would expect those above ground to grow much faster.

[4]Idem I, p. 111.

It was found that in general the small stalactites have a faster rate of drip than the larger ones. The average drip taken from a number of those in the early stages of development indicate about one drop in fifteen seconds. The rate for the larger ones is much less and quite variable. Allison comes to the conclusion that rapid vertical growth is favored by high air circulation, high temperature and high concentration and is opposed by rapid drip and high humidity. Large diameter, he remarks,[5] is favored by low air circulation, low temperature, high concentration and high humidity, and opposed by rapid drip. In this case the small stalactites, in their early stages of development, grow faster vertically and drip faster.

The average large stalactite here certainly does not weigh more than one-half ounce. On the assumption that the largest ones started to grow twelve years ago, shortly after the bridge was painted, it would take 3,840 years to produce one weighing 10 pounds and 38,400 years to grow one weighing one hundred pounds. These figures cannot indicate more than the fact that large stalactites are old. We are assuming that the length of time for accumulation was the maximum, twelve years, when a closer approximation would probably be less; how much less is impossible to determine.

THE GROWTH OF STALAGMITES.

The stalagmites which have grown on the steel girders and rock walls since 1919 vary considerably in length. Most of them are broadly rounded and others are narrow or of the mushroom type, varying from a fraction of an inch to two or three inches in height. One measured 2.22 cm. and another 3.1 cm. They are in some instances very porous with cavities in them which are lined with excrescences. They are made up of concentric shells or layers of growth. Some of the stalagmites are growing fast and others slowly, as indicated by their shape and width. Allison[6] observes, "A sharply convex face means a rapidly growing stalagmite and a blunt face means a slowly growing stalagmite." Several have splash cups which differ in width and depth; others have no splash cups. According to Allison, the deeper the splash cup the faster the drip, and the better the evaporation and the wider the splash cup,

[5]Idem. I, p. 113.
[6]Idem. I, p. 118.

the greater the fall. The stalagmites formed where the distance of fall was small had excellent but small splash cups, whereas those formed twenty feet below on the walk and curb are quite broad, several inches across, with gently convex surface and no splash cup.

The writer collected six stalagmites, four of which are reproduced as pen sketches. Number one is 3.33 cm., number two, 3.81 cm., number three, 4.13 cm., number four, 2.85 cm. in height. Number five, not shown in the sketch is 4.93 cm. high. Number one and two have hollow tubes running part way through them. The tube in number two is unobstructed, but the other in number one has transverse shells which divide the tube into partitions as in the stalactites. The writer is unable to offer an adequate explanation as to the origin of the tubes. All the stalagmites shown in the sketches were formed a few inches below the stalactites. It may be that solution removed enough of the interior of the stalagmite to produce the tube. Or perhaps a portion of the stalactite above broke off and fell in an upright position in the splash cup, allowing the stalagmite to grow around it. Another possible explanation; it may be that in this case, where the water fell but two or three inches, instead of spreading out as would certainly be true if it fell a great distance, the water would form a drop. Around its periphery and over its surface would form a delicate film of calcium carbonate. Drops from above would rupture this film at the top but the sides of the tube would be built up by constant addition of calcium carbonate at the periphery of the drop. In case the drip ceased sufficiently long, the film would form over the entire surface of the drop and ultimately become resistant enough to prevent its rupture by the falling drops. When this took place the growth would be by the addition of lime over the entire surface of the stalagmite. These explanations all have defects and the writer welcomes a satisfactory interpretation of the hollow tubes in the stalagmites. The stalagmites which formed on the curb and sidewalk, twenty feet below, are less than an inch thick and are broad, gently convex, almost flat on top and without splash cups. This condition, one might say, is due to the walking of pedestrians who would wear them down and prevent them from forming a narrow column. But this is not the case, because a number of typical stalgmites are forming on the curb where nothing interferes with their growth.

Stalagmite number three weighs an ounce. Assuming that it began to grow immediately after August 8, 1919, when the bridge was painted, it has taken twelve years for its accumulation. At that rate it would take one hundred and ninety years to form one weighing a pound and nineteen thousand, two hundred years to produce one weighing one hundred pounds. A closer approximation as to the rate of growth would be to take the average of a number of stalagmites. Because of the complex factors involved it is impossible to determine the rate at which stalactites and stalagmites accumulate over a long period of time. But we can say that large ones require a long period of time, not measured in hundreds but thousands of years.

CONCLUSIONS.

The rate of growth of stalactites and stalagmites is extremely variable, depending on such factors as the concentration of the solution, rate of drip and evaporation and loss of carbon dioxide from the solution. The rate of evaporation depends on the temperature, humidity and air movement. These factors, including the others mentioned, are so variable as to make it impossible to determine with any degree of certainty the age of a large stalactite or stalagmite.

The mode of development of stalactites and stalagmites, in their early stages, is well exemplified here. Furthermore the unusual conditions under which they are growing is worthy of the attention of those interested in their growth in caverns and elsewhere beneath the surface.

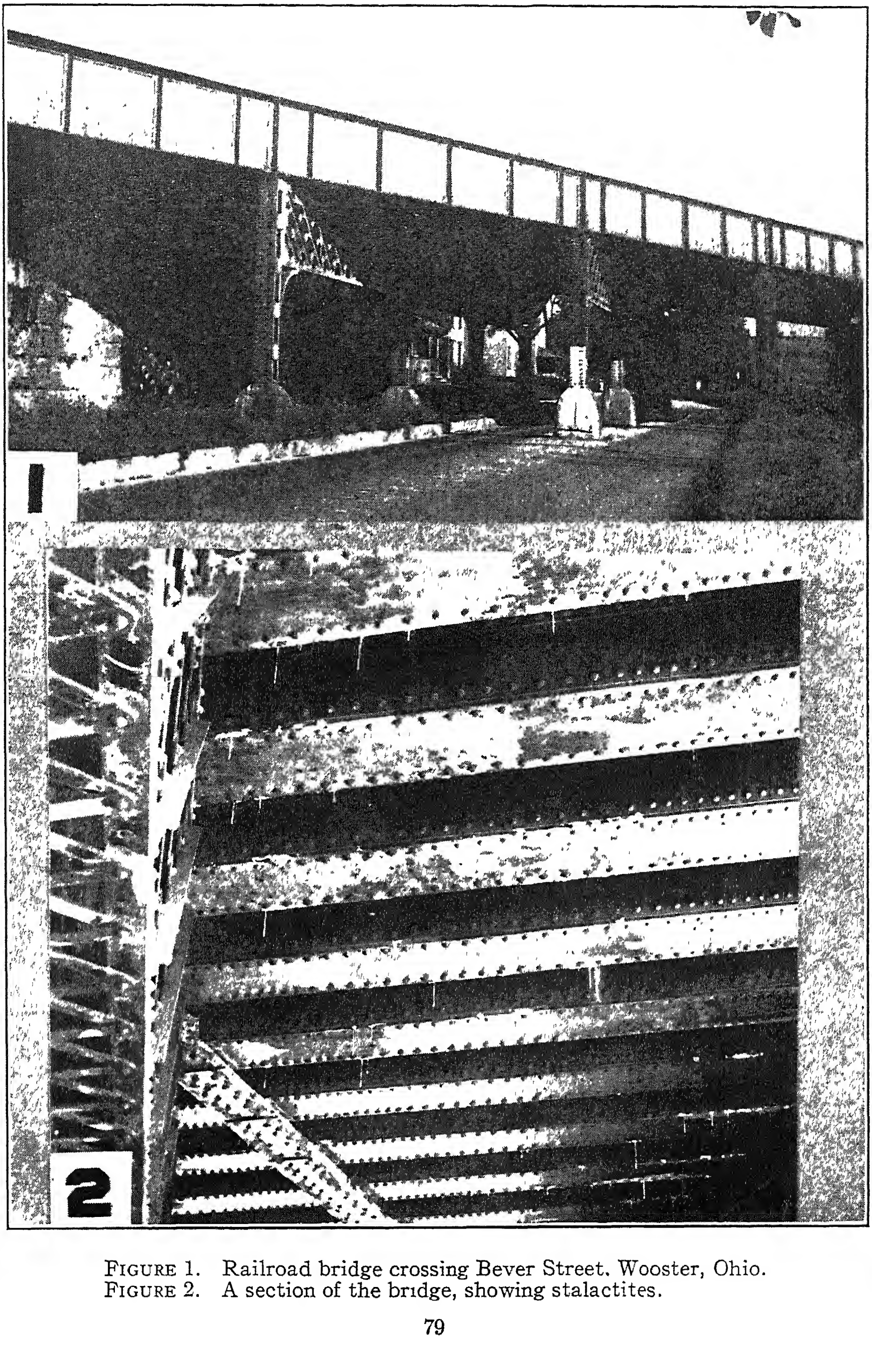


FIGURE 1. Railroad bridge crossing Bever Street, Wooster, Ohio.
FIGURE 2. A section of the bridge, showing stalactites.

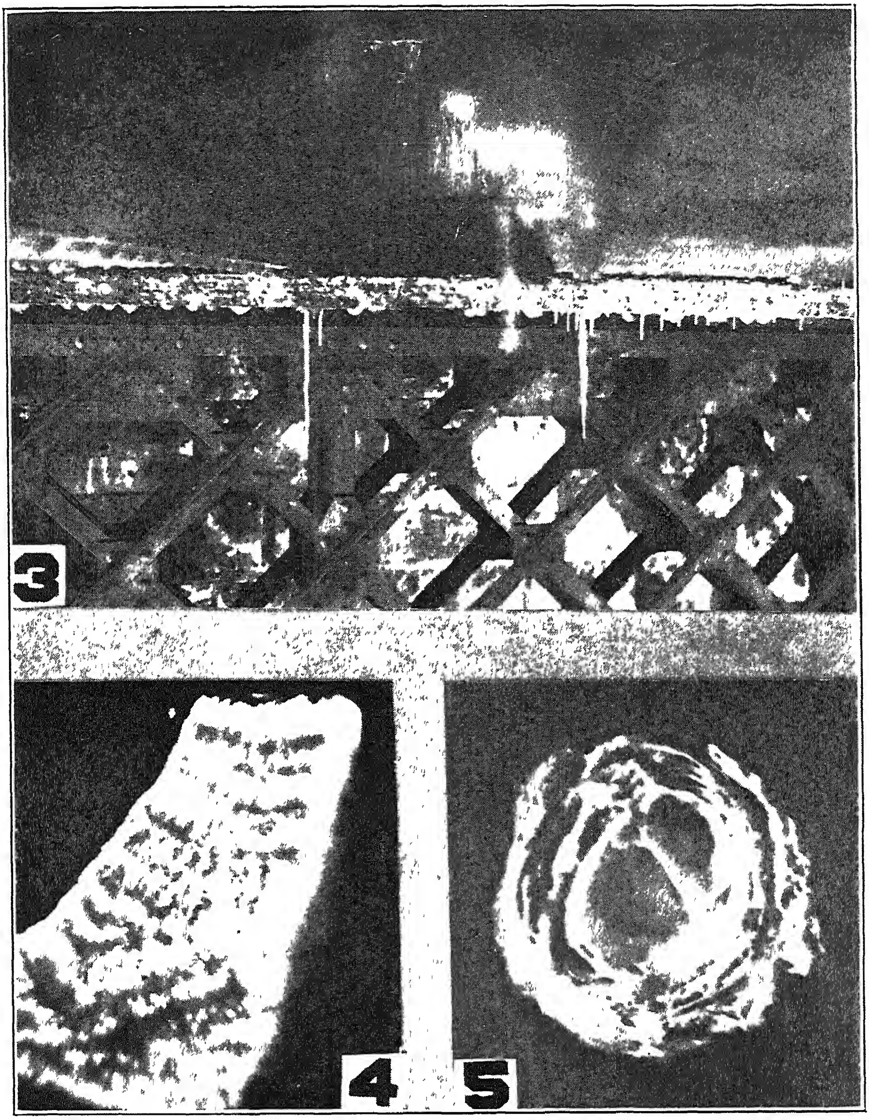
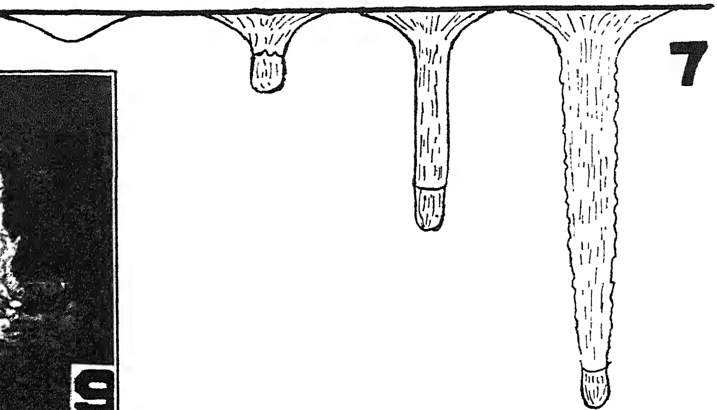


FIGURE 3. Section of the bridge showing two of the largest stalactites. The one on the left is 12½ inches long and about ½ inch in diameter.
FIGURE 4. Enlarged section of the thin shell at the tip of a growing stalactite. View of the inside, showing zones of growth. Note the rounded botryoidal excrescences, arranged in bands
FIGURE 5. Enlarged cross-section of a stalactite, showing the tube with a transverse, concave partition The original has a diameter of seven-sixteenths of an inch.



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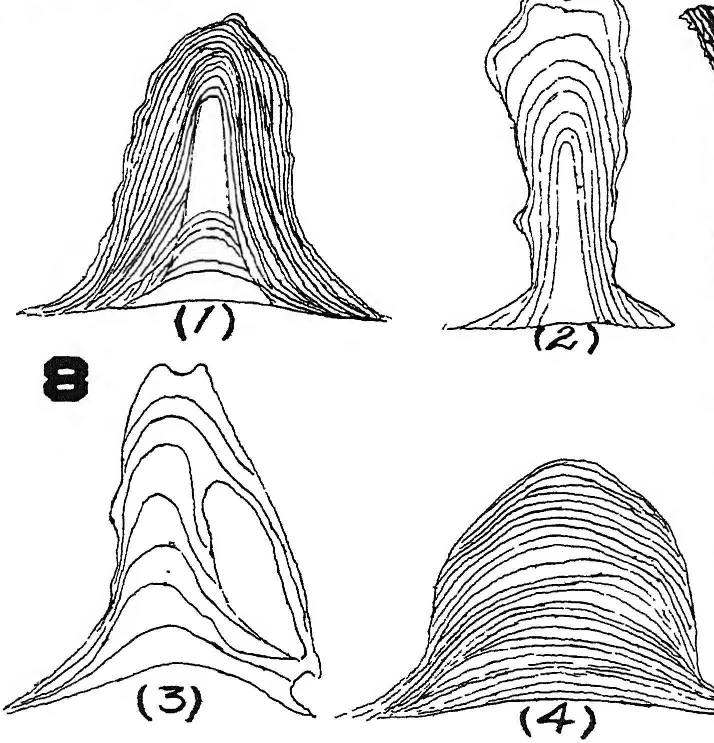

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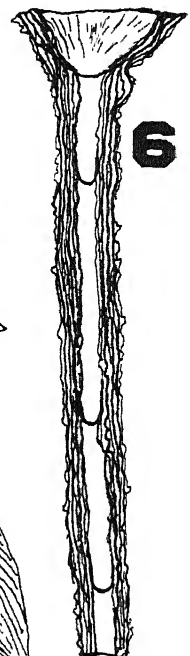

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FIGURE 6. Sketch of a longitudinal section of a stalactite, showing partitions in the tube.
FIGURE 7. Stages in the growth of a stalactite.
FIGURE 8. Sketches of longitudinal sections of stalagmites. Note the tubes in 1 and 2. Numbers 2 and 3 have splash cups.
FIGURE 9. Cross-section of a stalagmite, showing tube.

LEAFHOPPER RESPONSE TO COLORED LIGHTS.

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Many persons have observed leafhoppers flying about an electric light at night and collectors, especially, have taken many species there. With the passing of the old electric arc light and the universal use of incandescent bulbs, insect attraction to light has not been so great. Almost everyone can recall the swarms of insects around an arc light. It is true that the present street lights and other lights attract insects, but without doubt much of the ultra is lost in the modern lights and hence much of their insect attractiveness.

The writer first became interested in the response of leafhoppers to colored lights in 1927 while testing the response of corn borer moths to colored lights under outdoor conditions. The apparatus was inside a screened insectary, so the leafhoppers had to pass through two screens of 12-mesh in order to reach the lights. At times the leafhoppers were so numerous that they proved a nuisance while making observations.

The 1927 data are recorded in Tables I and II. All of these data were incidental to the regular corn borer light experiments so that the set up and procedure were identical with that of the corn borer. The apparatus was set up three feet from the ground, which was the average height of the corn at the peak of moth flight.

The leafhopper apparatus for 1930 and 1931 was the same as that used for the corn borer except that all the screen was removed except from around the bulbs. The data presented below are the result of two summers' work and it is hoped that they will give additional weight to some of the writer's former work on the response of the European corn borer to colored lights.

METHODS.

The apparatus consisted of a wooden framework divided into six compartments so arranged that the leafhoppers could enter from two sides and the top. Four heights were tried

TABLE I.

SHOWING THE RESPONSE OF LEAFHOPPERS TO COLORED BULBS. 1927.

Color of Bulb	Dates and Number of Leafhoppers Responding to Lights				
	July 14	July 18	July 26	July 31	Totals
Blue	0	0	1	0	1
Green	26	82	269	17	394
Ivory	58	216	480*	67	821
Buff	18	41	34	11	104
Brown	3	95	27	14	139
Red	0	14	1	1	16
Total	105	448	812	110	1475
Temp. 9 00 P. M.	62	76	73	69	
Temp. 10 00 P. M.	62	78	70	66	
Humidity	70 5		58	45	

*The leafhoppers came so fast on July 26 that only 480 were counted, as the writer and Dr. J. P Sleesman had to stop because they got into our eyes and mouths. There were at least 150-200 more that were not counted.

TABLE II.

SHOWING THE RESPONSE OF LEAFHOPPERS TO COLORED BULBS BY FIFTEEN-MINUTE INTERVALS. 1927.

Time	9:00	9:15	9:30	9:45	10:00	10:15	10:30	10:45	11:15	11:45	Totals
Blue	0	0	1	0	0	0	0				1
Green	8	7	11	15	17	18	14				90
Ivory	32	30	49	57	67	66	66				367
Buff	9	9	10	14	14	14	15				85
Brown	6	6	10	12	11	12	9				66
Red	2	1	1	1	1	1	2				9
Total	57	53	82	99	110	111	106				618
Blue			2	2	1		1	1	0	0	7
Green			11	18	37		36	76	82	61	321
Ivory			44	51	53		119	165	216	184	832
Buff			29	41	51		90	91	95	94	491
Brown			15	12	30		47	38	41	40	223
Red			4	6	8		12	18	14	13	75
Total			105	130	180		305	389	448	392	1,949

The data in the upper half of this chart were secured on July 31, 1927. The night was clear and cool. The temperature was 69° at 9:00 and 66° at 10:00 P. M. The humidity was 45, which was very low The data in the lower half of the chart were taken on July 18. The temperature was 76° at 9.00 and 78° at 10:00 P. M. Unfortunately no psychrometer was available so no humidity records were taken. These readings were taken at consecutive 15- or 30-minute intervals. The light was not turned off.

for the apparatus, ground level, 1½ ft., 3 ft. and 10 ft. The 1½ and 3 ft. levels proved most satisfactory. The colored electric light bulbs were the round 25-watt type of the following colors arranged in order, red, brown, buff, ivory, green and blue. They were ordinary outside colored bulbs that can be purchased at any electrical shop. The bulbs were not corrected for intensity of wave length. The physicist at the General Electric Laboratories at Nela Park, Cleveland, Ohio, informed me that the cost of having them calibrated would be unwarranted for a cheap bulb, as it would not hold constant long enough for practical use; hence, the bulbs were used as they came from the shop.

The apparatus after being placed in various locations was permanently set up on the lawn of the laboratory. A corn field adjoined the yard and all around were maple trees with a few fruit trees, such as apple, pear, cherry and plum.

RESULTS.

The summer of 1930 presented some very interesting comparisons. There was a period when the hot, dry conditions at Oak Harbor, Ohio, were similar to those in the desert (unpublished data). Following this, 3.04 inches of rain fell during three rains from July 21 to July 26 and that constituted the rain for the season. This was followed by another hot period from July 28 to August 4, when it turned cool and remained so for the rest of the summer. During the latter part of the season heavy dews occurred.

From a study of Table III it is seen that ivory attracted 453 leafhoppers out of a total of 909. Green was second in place of attractiveness, with brown, buff and red following in the order named. This same order of attractiveness was true for the corn borer. The reason that blue, a bulb normally expected to hold an attraction for insects, did not receive any is because the color covering on the bulb does not permit the transmission of the same intensity of light as that of the other bulbs. The correlation between color of light and response of leafhoppers is .55.

The odds calculated from the formula $t = \frac{r}{\sqrt{1-r^2}} \times \sqrt{n^1+2}$

as given by Fisher are 3,333,332 to 1 that there is a significant correlation.

TABLE III.

SHOWING THE RESPONSE OF LEAFHOPPERS TO COLORED BULBS. 1930.

COLOR OF BULB	DATES THAT EXPERIMENTS WERE CONDUCTED AND NUMBER OF LEAFHOPPERS RESPONDING																								To-tal
	June			July																			August		
	25	27	30	2	3	7	9	10	11	14	16	17	18	21	22	23	24	25	26	28	30	31	1	4	
Brown	9	5	1			5	3	9	11				31							11	4			36	125
Buff	8	8	3			8	6	7	13				16							20	3			31	123
Green	12	6	11			8	14	4	10				36							36	5			20	162
Red	3	0	0			1	5	6	0				9							6	4			12	46
Ivory	22	12	30			26	35	12	33				106							84	10			83	453
Blue	0	0	0			0	0	0	0				0							0	0			0	0
Total	44	31†	45			48	63	38	67				198							157	26			182	909
Temp. 8:00 P. M.	71	73	78	68	64	75	70	73	74	58	70	80	89	68	74	71	81	82	77	86	70	70	70	83	
Temp. 10:00 P. M.		69	72	58	53	66	69	72	69	52	66	73	82	72	72	67	72	75	74	83	63	64	66	77	
Average	71	71	75	63	58 5	70 5	69 5	72 5	71 5	55	68	76 5	85 5	70	73	69	76 5	78 5	75 5	84 5	66 5	67	68	80	
Humidity 8:00 P. M.	‡	46	63	83*	83*	64	67	66	74	83*	70	56	37	‡	‡	83*	‡	‡		56	84	83*	75	82	
Humidity 10:00 P. M.	†	72	‡	83*	83*	‡		69	90	83*	90	‡	41	‡	‡	83*	‡	‡		75	84*	83*	67	77	
Average	‡	59	63	‡	‡	64	67	67 5	82	‡	80	56	39	‡	‡	‡	‡	‡		65 5	‡	‡	71	79 5	
Average wind velocity, 8–10	1.1	5 2	2.8	4 0	1.2	*none*	9	2 1	1 2	2 4	2 8	2 8	*none*	3.1	1 8	.9	6	6	6	.6	*none*	1 0		*none*	
Rain								05						96	38				2 70						

†Quit at 9:00 P. M , when wind increased.
*Humidity was too high at the beginning of the experiment.
‡Hygrothermograph registered above 90 percent.

Referring again to Table III, the odds according to Fisher's formula $t = \frac{\bar{x} - \bar{x}_1}{s} \sqrt{\frac{(n_1+1)\,(n_2+1)}{n^1+n^2+2}}$ that the differences between the colored lights are significant is shown by the following:

The odds are 121 to 1 that there is a significant difference between ivory and green, but the difference is not great enough to show significant odds for green light compared with brown. The same is true for brown and buff, two colored bulbs which are very much alike, but the odds are 92.2 to 1 that buff is more attractive than red.

Ordinary 25-watt clear glass, mill type electric light bulbs attract leafhoppers but not as much as a 100-watt Mazda C. No leafhoppers were collected from these bulbs, but counts

TABLE IV.

Showing the Comparison Between Clear Glass Bulbs and Colored Bulbs.*

Date	Brown	Buff	Green	Red	Ivory	Blue	25 Watt Clear	50 Watt Clear	Total
June 30	1	3	11	0	30	0	2	8	55
July 7	5	8	8	1	26	0	5	11	64
July 9	3	6	14	5	35	0	8	18	89
July 10	9	7	4	6	12	0	2	3	43
July 11	11	13	10	0	33	0	2	8	77

*Counted but not collected.

were made. The results are tabulated in Table IV. In no case did the clear glass bulb attract as many as the ivory. On two occasions the 50-watt clear glass bulb attracted more than the green light.

It was repeatedly observed on nights that were not good for conducting the tests that leafhoppers came to windows through which the light from a 40-watt Mazda inside frosted bulb was shining. The leafhoppers were collected but in no instance did more come the same night. It is possible that when the lights were turned on in the room, the reflection through the window attracted those in proximity and they all came within a short period of time. The fact that once they were collected no more came to the window seems to confirm the above statement.

Table V shows the name and number of leafhoppers collected at each light. The determinations were made by Prof. Herbert Osborn.

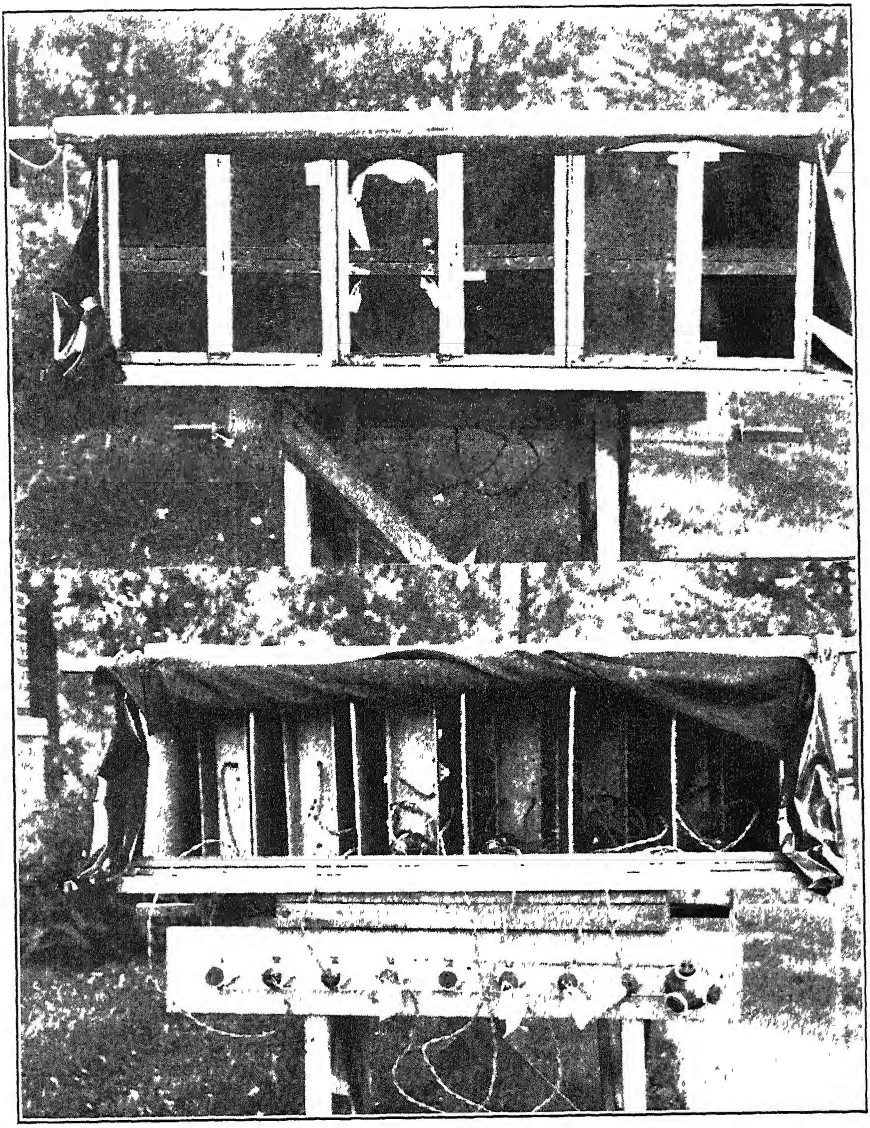
Due to the small numbers, no correlation can be made between species and color of light. From a study of the table, the first four species had the same relative attractiveness to the lights with no significant differences.

TABLE V.

SHOWING THE NAME OF LEAFHOPPERS WITH NUMBER COLLECTED AT THE COLORED BULBS. 1930.

NAME OF LEAFHOPPER	IVORY	GREEN	BROWN	BUFF	RED	TOTAL
Phlepsius irroratus	117	60	50	48	14	289
Deltocephalus inimicus	106	27	15	19	11	178
Cicadula 6-notata	80	46	9	7	6	148
Empoasca fabae	29	3	0	2	1	35
Thamnotettix nigrifrons	9	0	0	3	0	12
Scaphoideus immistus	6	0	1	0	1	8
Dikraneura fieberi	7	0	0	0	0	7
Xestpcephalus pulicarius	4	1	0	0	0	5
Gypona octolineata	0	2	1	0	0	3
Chlorotettix galbanata	1	2	0	0	0	3
Eutettix seminudus	0	0	0	2	0	2
Thamnotettix clitellarius	1	0	0	0	1	2
Dikeanura sp.	0	2	0	0	0	2
Draeculacephala inscripta	0	0	2	0	0	2
Draeculacephala mollipes	2	0	0	0	0	2
Idiocerus pallidus	0	0	0	1	0	1
Idiocerus suturalis	1	0	0	0	0	1
Gypona pectoralis	0	0	0	1	0	1
Totals	363	143	78	83	34	701

In 1931, in addition to the experiments with colored bulbs, the leafhoppers were also exposed to different wave lengths of light. The field apparatus consisted of a box framework which held six ray filters in their respective tin frames. The filters were 6½-inch squares manufactured by the Corning Glass Company. The colors and numbers of the filters were as follows: Red purple ultra, G586A; light blue green, G584J; signal purple, G55A; blue purple ultra, G585L; Pyrex and heat absorbing, G124J. The general set-up of the apparatus may be seen from the photographs (Plate I).



METHODS.

The light apparatus was set in a back yard with the following existing conditions: The lawn was mowed in front and back of the apparatus. On one side was a blackberry patch and garden while on the other, a grape arbor and garden. To the extreme front was another blackberry patch and garden, while the trees surrounding the area were soft maple, hickory, apple, pear and cherry.

Quantitative leafhopper counts were made at 15-minute intervals instead of mass collecting. The lights were turned on for 15 minutes and after the reading was taken they were turned off for the same period. In this manner a quantitative sample was taken and the period of flight determined.

RESULTS.

The season of 1931, although very well adapted for corn borer work, was not so good for night collecting. In 1930 there was a total of 3.09 inches of rain from June 25 to August 4 and 3.05 inches for the same period in 1931. However, in 1930, 3.04 inches of this rain came in three rains between July 21 and July 26, constituting the rainfall for the summer of 1930. In 1931 the same amount of rainfall was spread over the whole period. Although anemometer readings were not taken during 1931 there was noticeably more wind than in 1930.

A total of 5.59 inches of rain fell during the period from August 4 to September 16. The whole summer of 1931 was characterized by nights with heavy dew.

The 1931 colored bulb light experiments agree with those of 1930. See Table VI. There was not sufficient data for the 1931 tests with ray filters to draw any conclusions. However, from the results obtained pale blue green attracted 32 leafhoppers while pyrex was second with 25. The attractiveness of the other lights was as follows: Signal purple 23, purple ultra 16, heat absorbing 12, and red purple ultra 4. Of all the lights red purple ultra transmits the most ultra and attracts less leafhoppers. Pale blue green is the only filter not extending into the red end. Pyrex is a neutral glass and allows all rays to go through; so it is to be expected that the red end will offset the blue end. Signal purple and blue purple ultra transmit a band of red. Heat absorbing has a wide range and transmits rays of red as well as blue.

Leafhoppers responded to lights so long as the humidity

remained under 83 percent, but when the humidity increased above that point they ceased coming to the light. However, those already at the lights remained there. So far, the hiding places of the leafhopper at night have not been found.

A high temperature and low humidity are best suited for leafhopper response to light, but a high humidity, so long as it does not pass 83 percent, draws many leafhoppers. Referring to Table III it will be noted that nights having a high humidity did not attract leafhoppers. A combination of low temperature and high humidity is inimical to leafhopper attraction.

TABLE VI.

Showing the Response of Leafhoppers to Colored Bulbs. 1930.

Color	Number of Leafhoppers Taken							Total
	June 25	July 8	July 10	July 13	July 27	July 28	July 30	
Red	10	4	1	6	0	3	4	28
Buff	27	5	5	8	1	4	10	60
Brown	33	3	6	8	0	6	10	66
Ivory	48	20	10	36	4	11	33	162
Green	19	8	7	23	1	7	21	86
Total	137	40	29	81	6	31	78	402
Temp. 8:00 P. M.	82	83	75	73	72	82	88	
Temp. 10:00 P. M.	78	78	71	71	71	81	84	
Average	80	80 5	73	72	71 5	81 5	86	
Humidity 8.00 P. M.	76	80	88	73	82	68	60	
Humidity 10.00 P. M.	80	70	78	79	82	69	76	
Average	78	75	83	76	82	68 5	68	

Wind direction is important, but wind velocity is much more so. The apparatus was so designed to face the prevailing wind. Leafhoppers do not respond on nights when velocity is over 3½ miles per hour.

Catalepsy has not been observed in the leafhopper. Another interesting thing observed was that if conditions were favorable for a good leafhopper night, the insects would come to the lights despite the fact that the operator or others might be in the immediate vicinity.

Entomologists have reported occasional flights of leafhoppers at night. This habit of night flight is not restricted to any one species but represents a number of genera. No migration or exceptionally heavy flight was noticed such as occurred in 1927.

THE OCCURRENCE OF COAL AND MICA IN PLEISTOCENE DEPOSITS NEAR CINCINNATI.

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INTRODUCTION.

The occurrence of coal and mica in Pleistocene deposits has not been reported in southwestern Ohio. It may have some interest for two reasons. Because there is neither coal nor mica in southwestern Ohio, their occurrence in a deposit of transported material raises the question of their source of supply. In addition, the location of the deposit is such as to shed light on a problem of pre-glacial drainage.

LOCATION AND DESCRIPTION OF DEPOSIT.

One mile east of the point where the Little Miami river joins the Ohio river (Fig. 1, a) is a bluff cut into a deposit of fine sand covered with bowlder clay. The Miami river flows at this point southeastward in the abandoned valley of the pre-glacial Ohio, which flowed in the opposite direction. The old valley continues along the Miami, reversed in direction, about four miles and then curves northwestward through Norwood, northward through Lockland, and thence toward Hamilton, Ohio. (Fig. 1, b).

In 1929, this bluff was excavated for road-building purposes, and in such a fresh exposure the precise nature of the material was revealed.

The top of the exposure is about 615′ A. T., the base about 500′ A. T., a little above the flood plain of the river, which is here about 480′ A. T. Everything in the bluff below 575′ A. T. is sand, grading toward the top into very fine grains and very regularly laminated beds. (Fig. 2.) The upper half of the sand shows horizontal beds an inch or less apart with fine cross-bedding planes between, caused by gentle current action. (Fig. 3.)

At about 535′ A. T., the sand is cemented in place, perhaps due to the later spread of Wisconsin outwash waters through

the sand already then flanking the valley. At least the level corresponds with that of the Wisconsin water-laid terrace at Cincinnati.

Above 575′ A. T. the deposit is capped with bowlder clay, separated from the sand below by a band of limonitic cement with 10 to 12 inches of fine, laminated clay above it.

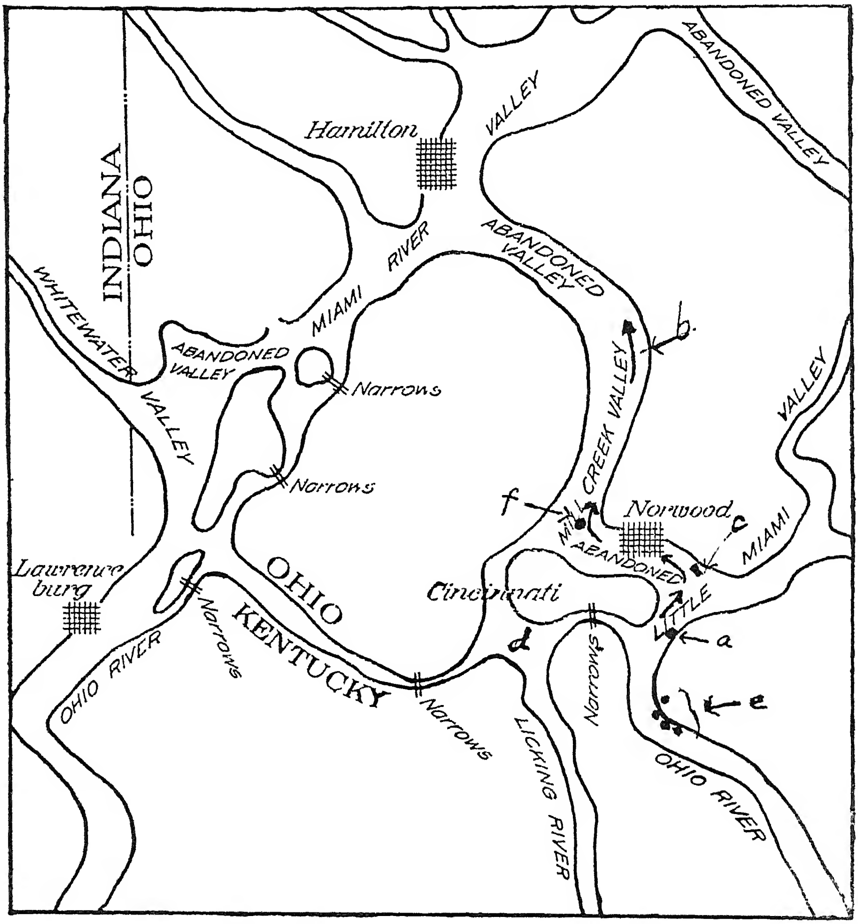


FIGURE 1. Sketch map of valleys in the vicinity of Cincinnati. (After Fenneman.)

a. Deposit with abundance of coal and mica.
b. Pre-Illinoian valley of the Ohio.
c. Gravel at surface in Illinoian valley fill.
d. Cincinnati basin.
e Glacial outwash capped with bowlder clay.
f. Coal and mica in "Norwood trough."

An interesting fold in the beds of sand, quite distinct from the cross-bedding and on a much larger scale was exposed in 1929. (Fig. 4.) Mention of it might be omitted from the description, because it has no apparent bearing on the origin of the deposit nor on the history of the drainage. However, it was an unusual feature, perhaps worthy of mention.

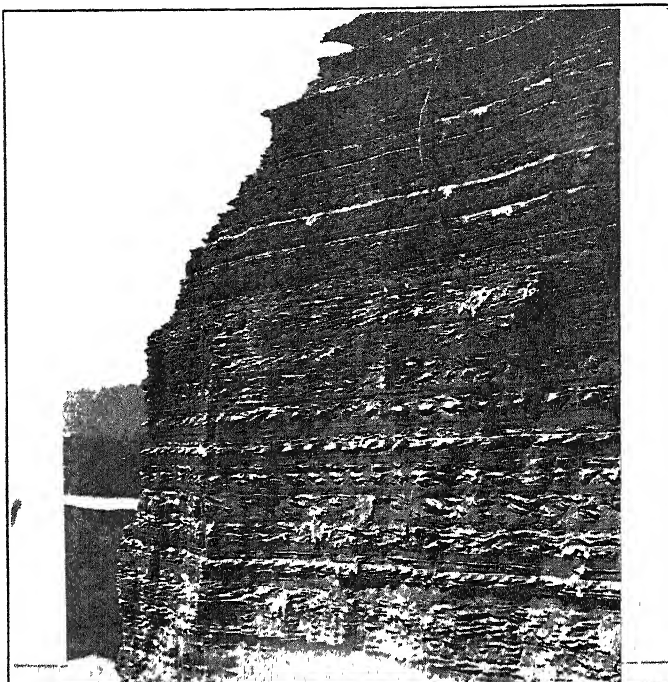
The fold was about two yards long and two feet high and was cut by the excavation in longitudinal section which was at approximately a right angle to the direction of the valley. The pressure must have been due to ice shove at a time when the water at this level was frozen over. The bedding planes were perfectly preserved across the fold. This may have been due to slight cementation of lime, in case a water level had been maintained for a more or less prolonged period, or, more probably to the cementation of ice at the time of folding.

ILLINOIAN TERRACE AT CINCINNATI.

The unconsolidated material of the deposit near the Miami has been considered a part of the glacial terrace of Illinoian age, represented by remnants in most pre-glacial valleys in the immediate vicinity of Cincinnati. This Illinoian valley fill is chiefly outwash, being built up of water-laid material, often gravelly, to the level of 575′ to 590′ A. T. and capped with bowlder clay to the level of 600′ to 625′ A. T., the latter deposited as the ice overrode its own outwash.

Exceptions to this rule are to be noted where, in restricted areas in the normal valley fill, there are exposures showing gravel at the top instead of bowlder clay. Such an exception occurs in part of Madisonville and part of the new town of Mariemont on the eastern side of the "Norwood trough," the abandoned valley of the ancestral Ohio. (Fig. 1, c). This gravel is at the top at the same level and side by side with the normal bowlder clay capping and may be interpreted to mark the course of a small stream on the ice.

There are also exceptions to the general condition of outwash and no bowlder clay in the lower part. In several exposures some bowlder clay appears in the outwash, but the many exposures in which the lower part is all outwash material would seem to rule out the possibility of any general advance of the ice earlier than the last event of Illinoian time. The cases in which bowlder clay appears in the lower outwash may be attributed, perhaps, to blocks of ice or even tongues of ice advancing part way down the valleys.



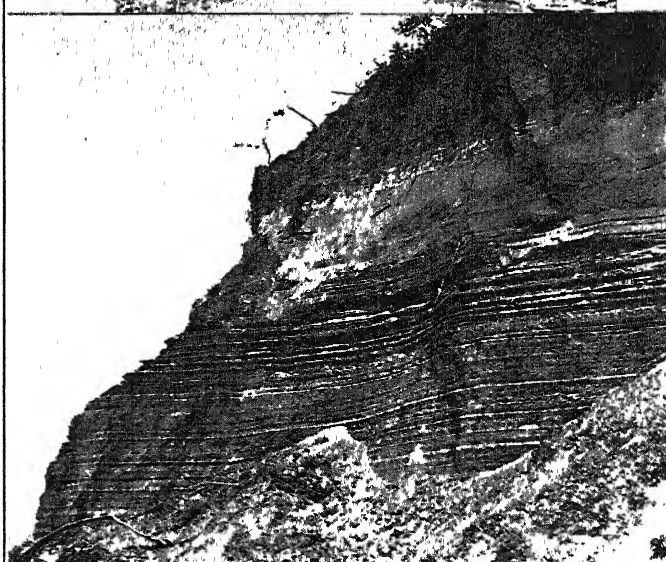


FIGURE 2. (Lower.) Deposit of fine sand interbedded with coal and mica, and covered with bowlder clay.

FIGURE 3. (Upper.) Finely laminated sand showing cross-bedding.

In the main, the Illinoian valley deposits at Cincinnati record a predominant outwash condition followed by a final, general advance of the ice. This is a statement of field observation. If it were not true, it would be a difficult matter to explain the existence of a practically level and concordant terrace of Illinoian age, abutting sharply against the valley walls which rise 200-250 feet higher. This can be seen in dozens of instances near Cincinnati.

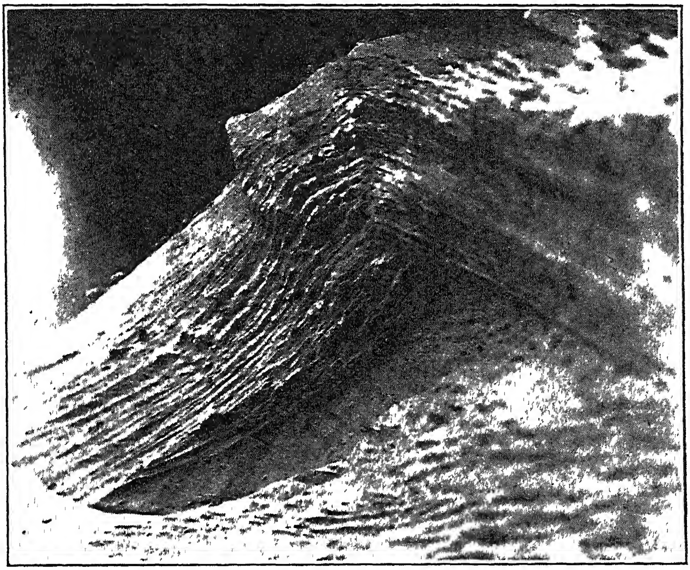


FIGURE 4. Fold in laminated sand.

OCCURRENCE OF COAL AND MICA.

It is in the fine sand between the cemented zone at 535′ A. T. and the limonite cement at 575′ A. T. that coal and mica occur abundantly. Nearly all the bedding planes are lined with black and some bands as wide as two inches are more coal than anything else. Also interbedded with the coal is an abundance of small mica flakes. This necessitates a common source of supply for both mica and coal. Rounded coal pebbles, usually small, but up to three inches in diameter are plentiful. These are very fragile and crumble in one's fingers when they are removed from the deposit where they lie imbedded. It seems doubtful whether any identification would be possible.

PROBLEM OF ORIGIN.

We have to do clearly with outwash from a coal field somewhere. It is also clear that coal is too fragile a sediment to be transported far in the form of pebbles. However, there are no coal beds in southwestern Ohio and no mica.

The nearest coal fields and the possible sources for such a supply seem to be three:

(1) There is coal in the syncline of Michigan. It is most unlikely, however, that any drainage except drainage from the melting ice ever could have found its way from Michigan into the Ohio river valley. It might possibly have been carried in the ice from Michigan and washed by the water in front of the ice into this valley deposit where it is now to be seen. However, this would be a long and devious journey for coal to endure. It seems probable, therefore, that we must look in another direction than that from which the ice came for the source of this Pleistocene deposit.

(2) The Licking river rises in the coal fields of eastern Kentucky and the sandstones associated with the coal beds are often rich in mica flakes. If the headwaters of the Licking can be shown to have discharged along the line of the ancestral Ohio instead of through the Cincinnati basin, as stated by Dr. Leverett,[1] it could have brought the coal, as well as the mica. The wash of its current, however, is badly needed to explain part of the water-cut rim of the Cincinnati basin, (Fig. 1, d) unless we wish to assume that this was carved chiefly in post-Illinoian time. One fact, at least, might serve to support such a view—that there are no remnants of Illinoian terrace anywhere in the basin.

However, if the Licking brought the coal and mica into the old northward curve of the ancestral Ohio, no drainage pattern has yet been traced which would make it possible.

(3) The most plausible origin for the coal and mica deposited near the mouth of the Little Miami seems to be the coal fields of southeastern Ohio, though the distance is greater than one would wish. It might have been carried westward by the Ohio at a time before the old valley trending northward through Madisonville and Norwood had been abandoned. The sand below the bowlder clay would thus be an old Ohio river deposit, not outwash from the ice at all.

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[1]Leverett, Frank. Monograph XLI, U. S. Geol. Sur.

Whatever drainage brought the coal must have continued until the final advance of the Illinoian ice, because the coal and mica continue upward in the deposit almost to the level of the bowlder clay on top. Just above the sand, as stated earlier, are finely laminated beds of clay and these are followed by bowlder clay. As the ice advanced down the old valley from the north, it must have dammed the northward flowing river, causing the deposition of lake beds during a time of temporary ponding. This was followed by the actual advance of the ice which changed the course of the stream to its present east-west direction.

TIME OF BREAKING OF THE DIVIDE AT MANCHESTER, OHIO.

Dr. Leverett says[2] that certain topographic features, chiefly gradation plains and relative widths of valleys, indicate that the divide at Manchester, Ohio was broken at the time of a pre-Illinoian glaciation, while the northward curve of the Ohio at Cincinnati probably continued until Illinoian time. If the laminated sand of this deposit is to be interpreted as a river-laid deposit, built up higher and higher as the advancing ice dammed the northward flowing stream, it is certain, as stated above, that such a drainage continued until the final advance of the ice in Illinoian time. If the coal and mica were transported by the Ohio from the east and not by the Licking from the southeast, it is certain that the Manchester divide had been broken before this deposit accumulated. There is neither coal nor mica west of Manchester.

Hence this one exposure, if it be interpreted correctly, proves definitely that the Manchester divide was broken earlier than the drainage changes were effected at Cincinnati and that the drainage changes at Cincinnati were not brought about until the final advance of the Illinoian ice.

It would also definitely date the breaking of the divide at Manchester as pre-Illinoian, in accordance with Dr. Leverett's evidence, except for one circumstance. This presents an alternative. There is no coal in the lower part of the deposit. It is not impossible that the divide was broken in early Illinoian time and that the old course of the Ohio at Cincinnati was maintained until the last event of the Illinoian. However,

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[2]Leverett, Frank. "Pleistocene of Northern Kentucky." Ky. Geol. Sur., Series VI, Vol. 31, 1929.

as Dr. Leverett points out, an enlarged Ohio must have cut the very wide Norwood trough (1½ to 2 miles) and not a little stream heading seventy miles to the east which has left old loops not wider than one-fourth to one-third mile. Such a large stream, at work during the long inter-glacial time preceding the Illinoian, could more reasonably be credited with completing the wide and deep (365′ A. T.) valley, and into such a valley it could have carried the coal and mica as its current was slackened by the approach of the ice. The coal and mica constitute a near-proof, if not a proof, of this bit of chronology.

OTHER PLEISTOCENE DEPOSITS IN THE VALLEY OF THE PRESENT OHIO.

Two miles south of the terrace described above and within a distance of two miles eastward along the north side of the present Ohio river, (Fig. 1, e) there are four good exposures of glacial material showing cross sections of 100 feet or more. Though these are so near, though they lie in the same valley which was used presumably by the ancestral Ohio, and though they are of about the same level, with water-laid material below and bowlder clay on top, they are obviously very different in origin. The outwash material forming the lower two-thirds or thereabout is largely heavy gravel and sand with coarse cross-bedding, and carrying an abundance of granite, diorite, and other Canadian pebbles. There is no coal or mica.

It is hardly possible that the same stream could have deposited at the same level, at the same time, coarse, cross-bedded gravel at one place and the finest laminated sand not more than two miles farther along its course. Besides, there seem to be no Canadian pebbles in the sand near the Miami. Clearly the two deposits are not parts of the same unit, though the valley is continuous and is thought to have been used in pre-Illinoian time by the same stream.

Some satisfactory explanation must be found. If the deposit near the Miami is in large part a terrace built by the ancestral Ohio river and the concordant terrace exposures along the present Ohio are composed largely of glacial outwash, the latter must have replaced the former in that part of the valley occupied at present by the Ohio river. As the ice advanced, covering the river-laid deposit with bowlder clay, there came a time when the ponded water spilled over the

divide to the west and established the present east-west course of the Ohio river past Cincinnati. This would have furnished a straightened course for the major stream and a natural outlet for the immense volume of ponded water. The heaviest outwash would have been carried into the major valley and the quickened velocity of the water would have carried out the finer sand, which had accumulated in earlier Illinoian time, and would have substituted the glacial outwash for the river-laid sand.

This would seem to the writer a satisfactory explanation of the anomalous data. It is supported by this further fact, that coal and mica are found interbedded with a similar fine sand exposed at Ivorydale near Winton Place, which lies in the northward continuation of the abandoned valley of the ancestral Ohio. (Fig. 1, f.) In the Ivorydale sand there is less of coal and mica, but the fineness of the material and the regularity of the bedding are very similar to that exposed near the Little Miami. The deposits are apparently bits of the same terrace with the same origin.

CONCLUSION.

The occurrence of an abundance of coal and mica interbedded with fine sand in the abandoned northward curve of the ancestral Ohio demands a source of supply for such foreign materials. The most plausible place from which they could have been derived seems to be the coal fields of southeastern Ohio. If this be the origin of the material, and the pre-Illinoian Ohio river be the agent of its deposition, the filling of the abandoned "Norwood trough" is here, at least, largely a river terrace of Pleistocene age rather than a deposit of material derived from the glacier.

If the ancestral Ohio brought the coal and mica, it must have had its source at that time east of Manchester, Ohio, because there is neither coal nor mica west of Manchester. The divide at Manchester must, therefore, have been broken before this terrace of Illinoian age was built, and it must have been in the building until the final advance of Illinoian ice.

THE DAILY PERIODICITY OF TRANSPIRATION IN THE TULIP POPLAR LIRIODENDRON TULIPIFERA L.*.

BERNARD S. MEYER.

Although a large number of papers have been published describing investigations upon the daily periodicity of transpiration in herbaceous plants very little information appears to be available upon this subject for ligneous species. There are almost no critical data of this sort for the important tree species of the deciduous forests of eastern North America. In this investigation the daily transpiration periodicity was studied in young tulip poplars (*Liriodendron tulipifera* L.). This species plays an ecologically important role over large portions of the eastern deciduous forest area. It is an important timber tree throughout much of its natural range, and has many advantages as a species for reforestation projects in suitable habitats. Hence studies on the fundamental physiology of this species appear to be desirable. A knowledge of transpiration rates and periodicity are necessary as integral parts of any study of the water relations and requirements of this or any other species.

A review of the more recent literature on transpiration reveals a few papers which have a direct bearing on this general problem. Dole (1924) determined the daily periodicity of transpiration in the white pine (*Pinus strobus* L.). In this investigation potted plants growing in a well watered soil were used. When grown in an uncontrolled atmospheric environment such plants showed a regular cyclical periodicity cf transpiration with the maximum at about 1 P. M. and a very low rate during the hours of darkness. The effects of differences in the water content of the soil, temperature, and relative humidity upon the rate of transpiration were also investigated.

Wilson (1924) determined the daily periodicity in transpiration rates for a large number of Australian xerophytes, including a number of ligneous species. He also used potted plants growing in well watered soils. The peak of the transpiration

*Papers from the Department of Botany, the Ohio State University, No. 283.

curve for the ligneous species, almost without exception, was found to occur in the middle part of the day, that is, between the hours of 11 A. M. and 3 P. M. In most of the species studied the night rates of transpiration were very low. These results are in general accord with published records of transpiration periodicity in herbaceous species.

Several field studies of the transpiration periodicities in ligneous species have been made by means of one from or other of the hygrometric paper method. Cribbs (1919, 1921) studied the daily march of "transpiring power" in the basswood (*Tilia americana* L.) by such a method. The results for trees growing in a number of different habitats were compared and considerable attention was paid to the effects of various environmental factors. The maximum rate of water loss was found to occur at different times of the day depending upon the habitat of the trees, and the diurnal march of atmospheric factors. In general, however, a cyclical diurnal variation in the rates of water loss was found for this species.

Meyer (1927) determined the transpiration periodicity for six species of Ohio trees and shrubs *in situ* by a modified form of the hygrometric paper method. In all of these species the maximum rate of water vapor loss as indicated by this method was found to occur relatively early in the day, usually between the hours of 8 and 10 A. M.

Blaydes (1928), using the same method as Meyer, studied the daily periodicity of transpiration in a number of species of plants native to Ohio, including several trees and shrubs. His results also show that the maximum rate of water vapor loss usually was attained during the mid-morning hours.

The hygrometric paper method, as commonly employed, does not measure transpiration in the usual sense of the word, but merely the ease with which the leaves of plants will lose water vapor to a standardized environment. The effects of diurnal variations in the atmospheric factors are largely or almost entirely eliminated. Because of its obvious advantages in the field this method has been widely used, but its limitations should be clearly realized. Apparently the general type of curve obtained by the hygrometric paper method differs somewhat from the general type obtained when the method of weighing potted plants is used. The latter method almost always indicates a transpiration peak in the middle part of the day, while the former more often indicates a peak in the curve

during the morning hours. It is clear, on theoretical grounds, that this difference is in part due to inherent differences in these two methods of measuring transpiration. However, it also seems almost certain that there are also real differences between the transpiration periodicities of plants growing under certain field conditions, and those growing in watered pots. A careful analysis of the exact methods used and the conditions under which the plants were growing is obviously necessary in evaluating results of this kind. A discussion of some of the limitations of the hygrometric paper method will be found in a previous paper by the author (1927).

The purpose of the present investigation was to study the daily periodicity of transpiration in the tulip poplar, and to obtain some approximate data, at least, on the magnitude of the daily transpiration loss from this species under the conditions of a fairly "typical" central Ohio summer day. The method chosen for the measurement of transpiration was that of weighing potted plants, which appears to be the most satisfactory method which is readily available for the determination of the daily periodicity in transpiration rates. The water content of the soil in the pots was maintained at approximately the moisture equivalent percentage. The results of the investigation represent, therefore, the daily periodicity curve for transpiration in young tulip poplars on a representative summer's day under conditions in which soil moisture deficiency, in itself, was probably not a limiting factor.

METHODS.

The tulip poplars used were grown especially for this investigation. Seeds of the 1928 crop were stratified over winter and sown in flats the following spring. About twenty-five of the resulting seedlings were later selected and each transplanted into a weighed earthenware pot 10 cm. in top diameter, and of known weight. Each of the pots was provided with 500 gm. of air dry loam soil which had a moisture equivalent value of 22.

After the transplanting of the seedlings was completed the pots were sunk for about one-third of their height in sand in a frame which was located out-of-doors. The sand matrix in which the pots were imbedded was watered from time to time during the growing seasons but otherwise the plants were exposed to the normal environmental conditions. The plants remained

in this location from early in the summer of 1929 until August 10, 1930. They had therefore completed practically two growing seasons before they were used in the present investigation.

For the specific purposes of this investigation seven plants were selected from the group, all closely similar in height and general appearance. These plants had stems about 15 cm. high and total leaf areas of between 2 and 3 square decimeters.

At about 7:00 P. M. on August 10 these pots were removed to an indoor bench, carefully brushed free from sand and allowed to stand until their outer surface had dried. Each pot was then fitted into a weighed metal shell and this set-up in turn weighed. A simple calculation then made it possible to add to each pot just sufficient water to bring the water content of the soil in that pot up to its moisture equivalent percentage.

This calculation was made possible by the fact that the weights of the shell, pot, and dry soil were known. The weight of the plant and the weight of the water held in the walls of the pot when in equilibrium with the same type of soil at its moisture equivalent were also known quite accurately from determinations on similar plants and pots.

As soon as the added water had been absorbed by the soil its surface was covered with a disk of cardboard, so cut that it fitted the inside walls of the pot snugly. This disk was cut radially to a central aperture through which the stem of the plant passed; a second aperture was provided through which a glass watering tube was inserted into the soil. This tube was provided with a rubber stopper. The stem of the plant was wrapped with cotton at the point where it protruded above the cardboard and this in turn covered with grafting wax. The entire soil surface as well as the gap between the rim of the pot and the rim of the metal shell was then sealed over with a layer of plastic clay. Finally the top of the pot was covered with a tinned metal disk which was radially cut to a central aperture to provide for the stem of the plant and was also supplied with an aperture through which passed the glass watering tube.

As soon as each pot was completely assembled it was weighed. Just before the experiment began each pot was reweighed and any loss of water which had occurred between the two weighings was restored.

At 10:00 P. M. on the evening of August 10 the seven potted plants were moved out into an open spot in the Botanical

Garden of the Ohio State University and supported on an especially built frame so that the metal shells would be shielded from any direct sunlight, without interfering in any way with the exposure of the plants. The next weighing of the pots was not made until 4 A. M. on the morning of August 11; weighings then followed at two hour intervals until 12 P. M. on this latter date. After each weighing any water which had been lost by transpiration was restored to the pot in units of 1 ml. The pots were always replaced in the frame so that the orientation of the leaves with respect to the environment remained unchanged throughout the 24-hour period.

A parallel series of determinations was made of wet and dry bulb thermometer readings, soil temperatures, light intensity, and wind velocity. The wet and dry bulb readings were obtained with a sling pyschrometer in the standard way. Soil temperatures were measured by thermometers set in the soil of two of the pots. The average reading of the two was recorded. These thermometers were calibrated against each other and with the psychrometer thermometers just before the series of determinations began.

Relative light intensity measurements were made with Eder-Hecht "Graukeil" photometers using Solio paper. It is recognized of course, that this method of photometry is subject to all the errors of any method in which sensitized paper is used and in which the surface exposed to the light is flat and horizontally placed. In spite of the known limitations of this method it gives, under the conditions under which it was used in this investigation, a fairly reliable indication of relative light intensities. The numerical values obtained with the instrument as used are of relative significance only. The photometers were exposed for full two hour periods, so that each value represents an integration of the light intensities for a two-hour period.

The wind velocity was measured by means of a wind meter which was oriented in the direction of the maximum wind velocity for 5-minute intervals once every two hours. The prevailing winds during the course of the experiment were from the north and northwest.

In general the day chosen for the determinations was a "typical" Ohio summer day except that the temperature was not quite as high as usual at this season. The day was clear, except for a very high thin film of cloud which passed across a

portion of the sky between the hours of 1:30 and 4:30 P. M. During a portion of this period this thin cloud was across the line of direct sunlight. According to the photometer readings, however, this cloud was too insubstantial to have any appreciable effect on the relative light intensity falling on the earth's surface.

At the conclusion of the experiment, determinations were made of the total leaf blade area for each plant, and also of the fresh weight and dry weight of the leaf blades for each plant. The main stem and petioles were both disregarded as transpiring surfaces in the final calculations, preliminary experiments with plants which had had the leaf blades stripped from them having shown that the magnitude of the transpiration from surfaces other than the leaf blades was less than the experimental errors in the method used.

DISCUSSION.

Table I presents in detail the data obtained concerning transpiration rates. These data are based on measurements made, except during a part of the first night, at two-hour intervals. They have been computed upon four different bases: grams of water transpired per plant, per square decimeter of leaf surface, per gram of fresh weight of the leaves, and per gram of dry weight of the leaves. The mean two-hourly value for the seven plants has been computed and also the total daily transpiration for each plant, as well as the mean for the total transpiration.

The figures presented in this table give a fairly definite conception of the quantitative values for the amounts of water transpired by young tulip poplars under what for the lack of any more precise term are here called "typical" Ohio mid-summer meteorological conditions. The figures as given on the basis of transpiration per plant are probably of greatest significance from the ecological standpoint. Although the variability in transpiration rates for these apparently similar plants, all growing under the same set of external conditions is striking and the number of plants used is insufficient to permit of statistical treatment, nevertheless the results would appear to be quite indicative of the amounts of water transpired by young trees of this species. The average total transpiration per plant was found to be 25.4 grams per day. Since soil water conditions were favorable this does not represent a minimum

transpiration rate for this species, but probably does represent the approximate transpiration rate under conditions suitable for growth.

TABLE I.

Daily Variations in the Transpiration Rates of Two-year Old Tulip Poplars.

Plant		August 11, 1930						Noon						Total
		12-2	2-4	4-6	6-8	8-10	10-12	12-2	2-4	4-6	6-8	8-10	10-12	
		Grams Water Lost per Plant												
1		0 1	0 1	0.2	0 9	5 0	6 1	5.2	3 9	4.1	2 7	0 3	0.2	28 8
2		0.2	0 2	0.3	1 0	3 5	4 2	3.7	3 6	3 6	2 5	0.3	0.2	23 3
3		0 3	0.3	0 3	1 5	3 9	4 6	4 1	3 0	2 8	1 9	0 4	0.3	23 4
4		0.2	0.2	0 2	1 4	4 2	4 4	4 0	3 6	3 6	2 0	0 3	0.3	24 4
5		0 2	0 2	0 3	1 6	3 9	3.8	3 7	3 0	3 2	1 6	0 3	0 2	22.0
6		0.3	0 3	0 5	2.0	5 2	6.7	6 4	5 2	4 8	2 1	0.7	0 2	34 4
7		0.3	0 2	0 2	1 6	4 1	3 5	3 5	3 2	3 1	1 6	0.3	0 1	21.8
Mean		0.2	0 2	0 3	1.4	4 3	4 8	4 3	3 6	3 6	2 1	0 4	0 2	25 4
	Leaf Area Dm2	Grams Water Lost per dm2 of Leaf Surface												
1	2 73	.04	04	07	.33	1 80	2 23	1 90	1 43	1 50	.99	.11	.07	10 51
2	2 08	10	10	14	.48	1 68	2 02	1 78	1 73	1 73	1 20	.14	.10	11 20
3	2 61	.11	.11	.11	.57	1 49	1 76	1.57	1 15	1 07	.73	.15	.11	8 93
4	2 58	.08	.08	08	.54	1 63	1 70	1 55	1 39	1 39	.78	.12	.12	9 46
5	2 79	07	.07	.11	.57	1.39	1 36	1.33	1 08	1.14	.57	.11	.07	7 87
6	2.57	.12	.12	.19	.78	2 02	2 61	2.49	2 02	1 87	.81	27	.08	14 38
7	2 57	.12	.12	08	62	1 59	1.36	1.36	1 24	1.20	62	12	.04	8 47
Mean	2 56	.09	.09	.11	.55	1.66	1.86	1.70	1.42	1 41	.81	.17	.08	10 11
	Fresh Weight Leaves	Grams Water Lost per Gram of Fresh Weight												
1	3.52	.03	.03	.06	.26	1 42	1.73	1.48	1.11	1 16	.77	.08	.03	8.16
2	2.67	.07	.07	.11	.37	1.31	1.57	1.39	1 35	1.35	.94	.11	.07	8.71
3	3.18	.09	.09	.09	.47	1 23	1.45	1.29	.94	.88	.59	.13	.09	7 34
4	3.03	.07	.07	.07	.46	1.38	1.45	1.32	1.19	1 19	.66	.10	.10	8 06
5	3.42	.06	.06	09	.47	1.14	1 11	1 08	.88	93	47	.09	.06	6.44
6	3.32	.09	.09	.15	.60	1 57	2.02	1.93	1.57	1.44	.63	.22	.06	10 37
7	3.27	.09	.09	.06	49	1 25	1 07	1 07	.98	.95	.49	.09	.03	6 66
Mean	3.20	.07	07	.09	.44	1.33	1.49	1 36	1.12	1 13	.65	.12	.06	7.96
	Dry Weight Leaves	Grams Water Lost per Gram of Dry Weight												
1	0 78	.13	.13	.26	1.15	6 41	7.82	6.66	5 00	5.26	3.46	.38	.26	36.92
2	0.60	.33	.33	.50	1.67	5.83	7.00	6.16	6.00	6.00	4.16	.50	.33	38 81
3	0 67	.45	.45	.45	2.24	5 82	6 86	6 12	4 47	4 18	2.83	.60	.45	34 92
4	0 57	.35	.35	.35	2.45	7 37	7.71	7.02	6.31	6 31	3.51	.53	.53	42.79
5	0.81	.25	.25	.37	1.98	4 81	4 69	4 56	3.70	3.95	1.98	.37	.25	27.16
6	0.71	.42	.42	.70	2.82	7 32	9 43	9 01	7 32	6.76	2.96	.99	.28	48 43
7	0.67	.45	.45	30	2 36	6.12	5.22	5.22	4.77	4 62	2.39	.45	.15	32.50
Mean	0.69	.34	.34	.42	21.0	6 24	6.96	6.35	5 37	5.30	3.04	53	.32	37.36

The diurnal periodicity of transpiration for this species is shown by the curve in Text Fig. 1. This curve is based on the mean two-hourly transpiration based on the square decimeter basis. Exactly the same type of curve would of course result if any of the other bases for transpiration were used.

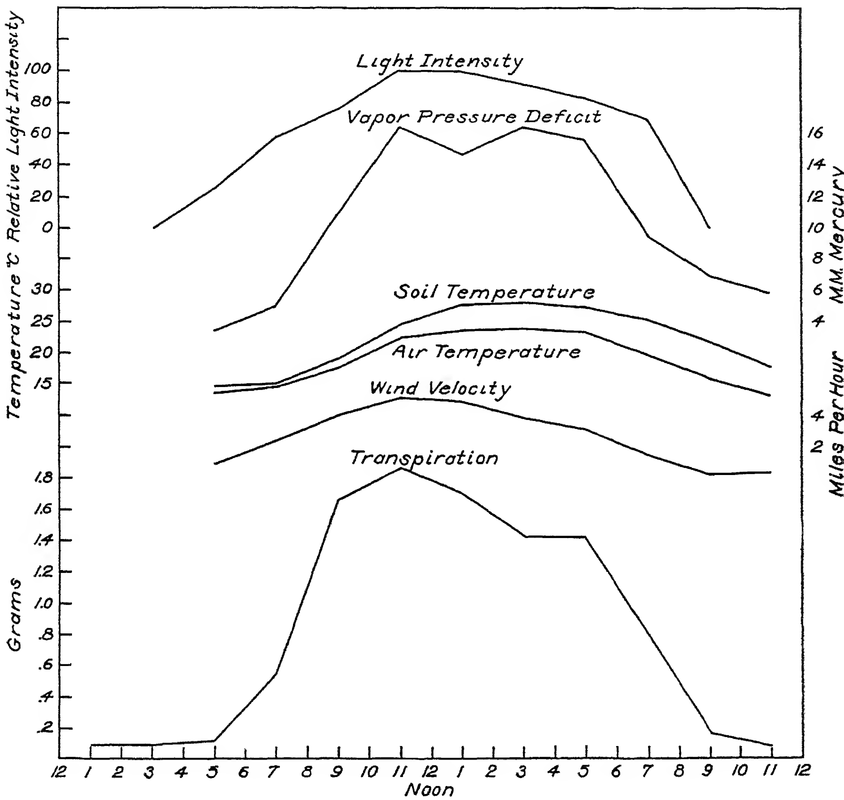

FIGURE 1. Diurnal variations in tulip poplar transpiration and in environmental factors.

Curves are also included in Text Fig. 1 for the daily periodic variation in the vapor pressure deficit, relative light intensity, soil and air temperature, and wind velocity. The vapor pressure deficit data were calculated from the wet and dry bulb thermometer readings.

A detailed discussion of the results does not appear to be necessary. In general the curve for the rate of transpiration is symmetrical, although it shows a slightly skewing towards

the morning hours, and there is a tendency for the curve to flatten out for a period during late afternoon. Transpiration during the hours of darkness is almost negligible and may be assumed to be entirely cuticular. The rate begins to rise between the hours of 5 and 6 in the morning, rises very rapidly between the hours of 7 and 9, reaches a peak about 11, declines slowly but mostly consistently until 5 P. M. after which the decline in rate is very rapid until the practically stable night rate is attained, apparently some time between the hours of 8 and 10 P. M.

This transpiration periodicity curve resembles very closely those obtained for various species of herbaceous plants by Briggs and Shantz (1916), Sayre (1919), and others, all of whom used methods very similar to those employed in the present investigation. It seems probable that the diurnal transpiration periodicity in woody plants is, in general, similar to that found in herbaceous plants growing in similar habitats.

The data on environmental factors are plotted graphically, not primarily in an attempt to explain the transpiration periodicity in this species, but rather to define in quantitative terms the environmental conditions to which the plants were subjected during the course of the experiment. Attempts to trace a causal relationship between the daily periodicity of transpiration and the daily periodicity of certain environmental factors have been made by a number of investigators, including some of those previously mentioned (Briggs and Shantz, 1916, and Sayre, 1919). A detailed analysis of the cause of transpiration periodicity is beyond the scope of this paper. The most definite correlations in these experiments are between transpiration periodicity and the daily periodicity of light intensity and to a somewhat less degree the daily periodicity in the vapor pressure deficit. This result would be anticipated on theoretical grounds. Light is the primary factor concerned in the opening and closing of the stomata. The vapor pressure deficit theoretically comes the closest of any readily determined environmental measure of indicating the steepnees of the diffusion gradient through the stomata.

Most of the recorded investigations of the daily periodicity in the transpiration rate in plants have been conducted with potted plants. Although this method offers many advantages from the experimental standpoint it is extremely doubtful if the results obtained always indicate the usual transpiration

rates as they occur in plants growing under field conditions. The customary procedure, which has been the one followed in the present investigation, has been to provide the plants with favorable soil water conditions, and usually to maintain at least an approximately constant percentage of water in the soil during the course of the experimentation. Such soil water conditions are not always present under field conditions. The available soil water is very apt to be deficient, and is probably often a limiting factor in transpiration. Daily variations in the amount of water present may also occur in natural soils. It seems certain, therefore, that because of these rather fundamental differences in soil water supply, that the daily periodicity curve for plants rooted in a natural soil will often differ from that obtained with potted plants in which the pots are well supplied with water. A difference in magnitude of the transpiration rates is certain, and differences in the trends of the curves might also occur. Of course, when a natural soil is supplied with water to approximately its moisture equivalent percentage there is every reason to believe that the transpiration curves for the plants growing in that soil and the curves for plants grown in pots containing the same soil and under the same soil water conditions would be essentially the same.

SUMMARY.

This paper reports the results of a study of the daily periodicity of transpiration in young tulip poplar trees on a "typical" Ohio summer's day. Transpiration was measured by the method of weighing potted plants. The soil in the pots was maintained at approximately the moisture equivalent percentage. Transpiration rates were calculated on four bases: per plant, per square decimeter of leaf surface, per gram of fresh weight and per gram of dry weight. All data are the averages for seven different plants. The results indicate that tulip poplar trees at the end of their second season of growth transpire about 25 grams of water per day per plant under such conditions as those chosen for this experiment. The peak of the transpiration curve was found to occur a little before midday. The maximum rate of transpiration recorded was 4.8 gms. per plant for the two-hour period between 10:00 A. M. and 12:00 M. Transpiration during hours of darkness was low and can be assumed to be entirely cuticular. In general, the transpiration periodicity for this species is similar to that

which has previously been described for a number of other species, mostly herbaceous. Measurements were also made of the daily march of soil and air temperatures, light intensity, wind velocity, and vapor pressure deficit. Of the environmental factors only the light intensity and vapor pressure deficit periodicity showed close correlation with transpiration periodicity.

LITERATURE CITED.

Blaydes, G. W. 1928. A survey of rates of water loss from leaves Ohio Jour. Sci. 28: 99–118.

Briggs, L. M. and H. L. Shantz. 1916. Hourly transpiration rate on clear days as determined by cyclic environmental factors. Jour. Agr. Res. 5: 583–649.

Cribbs, J. E. 1919. Ecology of *Tilia americana*. I. Comparative studies of foliar transpiring power. Bot. Gaz. 68: 262–286.

1921. Ecology of *Tilia americana*. II. Comparative studies of foliar transpiring power. Bot Gaz. 71: 289–313.

Dole, E. J. 1924. Studies on the effects of air temperature and relative humidity on the transpiration of *Pinus strobus*. Vermont Agr. Exp. Sta. Bull. 238.

Meyer, B. S. 1927. The measurement of the rate of water-vapor loss from leaves under standard conditions. Amer. Jour. Bot. 14: 582–591.

Sayre, J. D. 1919. Factors controlling variations in the rate of transpiration. Ohio Jour. Sci. 19: 491–509.

Wilson, H. W. 1924. Studies on the transpiration of some australian plants, with notes on the structure of their leaves. Proc Roy Soc. Victoria 36: 175–237.

Are Healthy People Interested in Health?

It would be simple enough to sell ideas of health to the inmates of a hospital or sanitarium, but to do the same to a group of college students who, as a rule, have plenty of health, is a different task and requires a super sales talk. It is of primary importance, however, that this very group of healthy youngsters become interested in preserving that which they already have.

In their recent book, "Fundamentals of Health," Kirkpatric and Huettner have attempted to utilize those phases of biology which their experience has shown them to be of most interest to their students. Capitalizing upon this interest they have made use of it as a basis for presenting their "fundamentals" for health.

For the most part the book is very well done. The opening chapter on the "Evolution of Man" is the weakest. The attempt to develope an evolutionary background is often teleological and unsound. But the book contains much of value upon foods, embryology and reproduction, immunity and immunology, public health relations, etc. The matter of sex is especially well treated in a frank and open manner as it should be.

Diagrams, cuts and tables are profusely used to advantage. There is an excellent list of references for further reading with each chapter and a glossary of terms which should be useful to the student.

Fundamentals of Health, by KIRKPATRIC AND HUETTNER, 8 vo.: VII, 576 pp., Ginn and Company, 1931.

FLOWER PRODUCTION IN THE LEMNACEAE.*

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The general evolutionary movement in the Lemnaceae or duckweeds apparently has been from frequent flower production to rare flower production to a total loss of the ability to produce flowers. From the original ancestral forms, which perhaps depended entirely upon seed production for propagation, have evolved these minute plants which now are propagated almost entirely or solely by vegetative methods. The family consists of four genera and about 26 known species.

In *Spirodela* flowers are very rarely produced. Wiggers, 1780 (36), records the first discovery of *Spirodela polyrhiza* (L) Schleiden in flower by Grauer, a young botanical student. Flowers of this species were first discovered in the United States at Staten Island, N. Y., by Leggett, 1870 (22a). Others who have recorded flowering are Willdenow, 1805 (37), Schleiden in Germany, 1839 (30), Griffith in India, 1851 (14a), Nees von Esenbeck as recorded by Hoffman, 1840 (17) and Ludwig, 1909 (24b), Gillman, Belle Isle, Detroit River, Michigan, 1871 (13b) and 1881 (13c), Rostowzew, 1901 (28a) and Saeger in Missouri, 1929 (29). *Spirodela punctata* (Meyer) Thomp., collected by the Capt. Wilkes Expedition in Terra del Fuego, South America in 1839, was described as flowering by Thompson, 1898 (31). Flowers of *Spirodela oligorhiza* Kurz were described by Kurz, 1865 (21). A fourth species found in Australia, *Spirodela pusilla* Hegelm, apparently flowers more commonly. than any species of the genus, Hegelmaier, 1895 (15a).

The flowers and even matured fruits of *Lemna* have been found occasionally in all species and many have been studied in detail. Micheli 1729 (25) first records flowers of *Lemna gibba* L. Ehrhart, 1779 (9), Wolff, 1801 (39), Palisot, 1816 (26), Wilson, 1830 (38), Brongniart, 1833 (4), Richard, 1833 (27), Schleiden, 1839 (30), Dalgleish, 1926 (16), and a number of other authors have recorded flowers of this species. *Lemna trisulca* L. apparently was first reported in flower by Wolff,

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1801 (39) and had since been found flowering under natural conditions by a number of authors. *Lemna perpusilla* Torrey was first described and also found in flower at Staten Island, N. Y., by Torrey, 1843 (32), and again by Leggett, 1870 (22a), and studied in detail by Blodgett, 1914 (2a) and 1923 (2b).

Lemna minor L. was the only duckweed known in flower to Linnaeus, 1763 (23). This species undoubtedly blooms more frequently than any other as it has been reported in the flowering condition by no less than thirty authors. Some flowering plants were observed by the writer during the summers of 1928, 1929, 1930 and 1931. In May, June, July, August and September of the drowth period of 1930, flowering plants were found in abundance in many widely separated localities of Ohio. Wolff, 1801 (39), Vuyck, 1895 (34a), Kalberlah, 1895 (19), Rostowzew, 1901 (28a) and 1905 (28b) and Goebel, 1921 (14) gave detailed descriptions of the reproductive structures. Caldwell, 1899 (5), made a complete life history study of the species.

Flowers in the genus *Wolffia* are extremely rare, difficult to detect because of their small size, and have never been found for two species, W. *microscopia* Griff. and W. *cylindracea* Welw. W. *papulifera* Thomp., a species known only from Missouri and bordering states and described by Thompson in 1897 (see 1898, 31), was unknown in flower until discovered by Saeger in 1927 and 1928 (see 1929, 29). Flowers of W. *brasiliensis* Weddell were first described by Weddell, 1849 (35), W. *arrhiza* (L) Wimmer by Franchet, 1864 (12), W. *hyalina* (Delile) Hegelm., by Hegelmaier in 1865 (15), W. *columbiana* Karsten by Karsten in 1865 (20) and by Austin, 1870 (1), W. *repanda* Hegelm. by Hegelmaier in 1868 (15b), W. *Wetwitschii* Hegelm. by Hegelmaier in 1868 (15b), and W. *punctata* Griseb. mentioned or described vaguely by several writers. Additional known occurrences of flowering in the genus are certainly rare as the writer was able to secure very few other definite records in making an exhaustive survey of the literature.

In the genus *Wolffiella* reproduction is entirely by the vegetative method as none of the four known species (W. *floridana* (J. D. Smith) Thomp., W. *gladiata* Hegelm., W. oblonga (Ph) Hegelm., and W. *lingulata*) have ever been observed in the flowering condition. The ability to produce

flowers apparently has been so completely lost that probably they are never produced by plants in nature. In *Wolffiella floridana*, at least, it is even doubtful as to whether the flowering potentiality could be made to find expression as the result of favorable physiological conditions.

It has been noted by the writer a number of times and by others (Gillman, 13a, Leggett, 22b, and Saeger, 29), that bodies of water having one flowering species are likely to also have a second or a third. Apparently then, even in nature, unusual combinations of either chemical or non-chemical environmental factors may develop locally in a small body of stagnant water, and make possible the expression of the flowering potentiality which still exists in *Spirodela*, *Lemna*, *Wolffia* and perhaps in *Wolffiella* as well. These necessary combinations do not commonly occur, but certain species, such as *Lemna minor* and to a lesser extent L. *trisulca*, are much more responsive to these effects than the other members of the family.

During the drowth period, or the months of May to September inclusive, of the summer of 1930, dozens of small bodies of water supporting duckweed populations dried up completely or were greatly decreased in size. In a number of these habitats, the water supply failed for what, certainly, was the first time within recent history or perhaps since the settlement of this state. All aquatic vegetation was subjected to most unusual growth conditions. In many shallow pools, duckweeds of several species were left stranded on mud flats with a steady but limited water supply. In other cases, the lowering waters left tangled masses of *Lemna* or *Spirodela* draped about stems of *Cephalanthus occidentalis* or other aquatic shrubs. If the plant mass dipped into the water beneath, a limited but sufficient water supply for life was maintained. During this period some field work was done in each one of the 88 counties of Ohio. Under these conditions two species were found in flower in a number of widely separated localities of Ohio from May 20 to Sept. 6, 1930.

Lemna minor and L. *trisulca* were found in flower at Suffield Bog (Portage Co.), Venice (Erie Co.), Buckeye Lake (Perry Co.), Baumgardner's Pond (Franklin Co.), and Calamus Pond (near Circleville; Pickaway County). In addition L. *minor* alone was found in flower at Jasper (Pike Co.), Athens (Athens Co.), Fredericktown (Knox Co.), Indian Lake (Logan Co.) and

Tamarack Ditch (Williams Co.). No other species were found blooming although large areas of plants growing in more than 180 localities of the state were studied, all of our 7 Ohio species being represented.

In 1928, 1929 and 1931, a similar survey revealed only a few scattered instances of flowering, and then flowering plants were always decidedly uncommon. As to what environmental factors accompanying the drouth, were responsible for the unusual flower production in 1931, can only be a matter of speculation. In many instances, observations suggested that altered mineral content of the water medium, increased water and air temperatures, or light effects might be of most importance.

Flowering plants, without exception, were never found in shaded areas, even though abundant flowering material might be found in better illuminated areas a few feet distant. In most cases, flowers were most abundant in areas most exposed to sunlight. Correlated with this was the observation that flowering plants were invaribly found abundantly only in water areas of unusually high temperatures and were absent in colder portions. In addition, since *Lemna minor* flowered in only about 8% of all of the localities visited, and since the visible environmental characteristics of many localities appeared to be almost the same, it was suggested that the chemical nature or mineral content of the water medium might inhibit or be an important factor in promoting flower production.

In *Lemna minor*, flowering plants observed were usually somewhat above average size for the species, commonly light green in color and with long roots, and invaribly quite cavernous. In *Lemna trisulca*, the extremely modified flowering plants of the species were very light green in color, were quite cavernous and were produced by buoyant plants of medium size having relatively short internodes. With both species, flowering plants produced were similar in general appearance to those previously produced by experimental methods as described below.

In all available literature concerning the Lemnaceae, the writer has found but one reference concerning the production of flowering plants outside of their natural environment. Saeger, 1929 (29), found that cultures of *Lemna minor* growing in dilute mineral solutions (Knop's), sometimes produced

flowers. Other species of *Lemna* grown failed to produce flowers. No references to any experimental attempts to induce flower production, have been found. Therefore, it seemed desirable to make a test of all possible treatments and environmental controls which might alter physiological processes and induce or lead to control of flower production. This paper is largely a revision of a previous paper written in May, 1929, summarizing a series of experiments conducted from Nov. 1928 to May 1929. The writer wishes to acknowledge his indebtedness to Dr. E. N. Transeau and Dr. B. S. Meyer, for their many valuable suggestions and criticisms in this research and to Dr. Robert B. Gordon and Mr. W. C. Camp for their assistance in taking the photographs and microphotographs of flowering plants.

Previous experimental work had demonstrated that there were remarkable differences between our 7 Ohio Lemnaceae species in their reactions to various environmental conditions. This suggested that each species might require its own particular treatment or that those influences which had favored flower production in other plant families, might not apply to this one. Each species, perhaps, has reached its own particular physiological level in regard to the possible expression of the flowering potentiality. The factors inhibiting flower production, which have come into the systems of some of the species in the evolutionary process, are perhaps so dominant that they may never be overcome, even under artificial conditions. From the above, it will be seen that the problem of inducing flower production is a very complex one. The writer has been successful in producing flowers in four species and one variety of the genus *Lemna* and in one species of the genus *Wolffia* by experimental methods affecting the physiological condition. Flowers were produced in *Lemna trisulca*, L. *cyclostasa*, L. *minor*, L. *minor* var. *purpureus* L. *minima* and *Wolffia columbiana*.

The experiments showed that for flower production the following conditions are necessary:

1. Healthy mature plants making good vegetative growth and with an accumulation of a food reserve.

2. Some environmental influence which will rather suddenly check normal vegetative growth with the possible diversion of the accumulated reserve to flower production.

3. In some species, such as *Lemna trisulca*, which undergo a marked transformation of the vegetative form at the time of blooming, plants should be selected for treatment which are as near as possible in appearance to the flowering form as such transformations do not come about rapidly. Not all growth forms are equally responsive to experimental treatments.

In all of the experimental work with flower production, *Spirodela polyrhiza*, *Lemna trisulca*, L. *minor*, L. *minor* var. *purpureus*, L. *cyclostasa*, *Wolffia columbiana*, W. *punctata* and W. *floridana* were used. Plants were grown in about 4 inches of water in glazed culture jars of 28 sq. in. of water surface area and under greenhouse conditions. In every experiment attempted, lots of 1000 or more plants of each species were used to make it possible to observe any results produced, on large numbers of individuals. In many cases, smaller cultures of 1 to 25 plants of each species were treated similarly and used as checks. The record of the various experiments attempted with the results obtained is as follows:

1. Mineral Salt Deficiency.—During the experimental work approximately 850,000 plants of all species (about 460,000 of *Lemna minor*) were "starved" by growing in various nutrient solutions known to be deficient in one or more of all of the elements considered essential, in tap water or in various soil-water solutions. The plants became small in size, produced resting forms in many cases and eventually died, but as far as is known, not a single plant produced flowers. The "starvation" process is a gradual checking of vigorous vegetative growth with the loss of any food accumulation or reserve which might favor flower production if present. This method, then, gives no promise of desired results.

2. Nutrients. All of the species were grown in numerous nutrient solutions of varied combinations and concentrations. Many of the unbalanced nutrients produced size reduction or resting forms. Some produced marked modifications of the vegetative form as in *Lemna cyclostasa*. Nutrients with an excess of nitrates or those containing abundant organic matter, usually produced vigorous vegetative growth but without exception, there was no flower production. The following nutrients were also tested: Knop's, Knop-Bottomly, Detmer-Moor, Detmer's, Pfeffer's, Crone's and Shive's. Several others were used in a few instances but no plants grown produced flowers.

3. PHOTOPERIODISM. Several of the species made vigorous growth during the reduced light of the winter months if other environmental factors were satisfactory. Seven species were grown for five months under 24 hour light in various media. All produced somewhat better growth than the controls under natural light but *Spirodela polyrhiza* exhibited a marked tendency to develop excessive pigmentation. This species and the Wolffias also produced resting forms freely. When these plants were suddenly changed to shorter light periods, no flower production took place and no other very pronounced modifications occurred. During the winter months, cultures of each species were subjected to 2, 4 and 6 hours of artificial light daily over a three-week period in addition to the normal sunlight period. These cultures made only slightly better growth than the controls under daylight. Flowers were never produced in any of these experiments.

4. LIGHT INTENSITY. Plants of 7 species were subjected to five different light intensities of artificial light for 2, 4, 6, 8 and 10-week periods by various degrees of shading, with marked effects resulting in the vegetative form as in *Spirodela polyrhiza*, but no plants developed flowers.

5. CHEMICAL EFFECTS. Approximately 60 common chemical substances were added in varying quantities to the media in which six species of duckweeds were growing. Results were negative except in one case. Flowers of *Lemna minor* and L. *trisulca* were abundantly produced by treatment with dilute sodium hydroxide. This treatment failed to produce flowers in any of the other species and often failed to produce them in these species when repeated. In each case, a culture solution with a mat of plants of approximately 28 square inches was treated. A small amount of the dilute sodium hydroxide was added to the medium for several days until a few of the plants showed signs of injury. The amount required varied considerably. Then treatments were stopped. Usually from 1% to 10% of the plants were killed, the remainder nearly or entirely stopped vegetative growth and a few of them were thrown into the flowering condition. The first treatments began March 28, 1929 and the first flowers were discovered on April 15, 1929. Some flower production continued up to May 16, 1929. The mediums gradually became less alkaline and the hydrogen ion concentrations of the mediums at the time for the greatest

flower production on April 22, 1929 is shown. No flowers were produced in any of the check cultures. The records for each culture are as follows:

Species and Collection	First Flowers	Percent of Plants Flowering	p. H. at Time of Flowering
1. *Lemna minor* Coll. at Baumgardner's Pond, Franklin Co., 3-27-29	4-15-29	15%	7.6
2. *L. minor* Coll. at Baumgardner's Pond Bog, 3-27-29	4-17-29	12%	7 21
3. *L. minor* Coll. at Cranberry Is., Buckeye Lake, 3-25-29	4-16-29	26%	7.33
4. Same as No. 2	4-17-29	20%	7 43
5. Same as No. 3	4-19-29	10%	7 41
6 *L. minor* Coll. at Westerville, Franklin Co., 3-6-29	4-15-29	20%	7 21
7. *L. minor* from De Land, Fla., 3-1-29	4-16-29	5%	7 35
8. *L. trisulca* Coll. on Cranberry Is., Buckeye Lake, 3-25-29	4-19-29	8%	7.16
9. *L. trisulca* Coll. at Baumgardner's Pond Bog, 3-27-29	4-23-29	30%	7 21

6. Ultra-violet Rays. Flowers of *Lemna minor*, L.m. var. *purpureus*, L. *trisulca* and L. *cyclostasa* were abundantly produced in cultures treated with ultra-violet rays from a mercury quartz vapor lamp. Sixteen earthenware culture jars of approximately 28 square inches of water area each were prepared. To each was added a small amount of rich clay loam soil containing considerable organic matter and then filled with tap water. Each jar was given the following duckweed population. The numbers of each are only approximate: *Spirodela polyrhiza* 75, *Lemna trisulca* 100, L. *minor* 150, L.m. var. *purpureus* L. *cyclostasa* 150, Wolffia *columbiana* 400, W. *punctata* 200 and W. floridana 50.

Every other jar of duckweeds was selected as a control and the others were subjected to the ultra-violet treatment. A 110-Volt lamp, at a distance of 30 inches was used. The time

of the treatment of the 8 culture pairs was 8, 16, 27, 39, 51, 63, 75 and 87 minutes respectively. Treatment was given on April 19, 1929 and the first flowers appeared 13 days later on May 2, 1929. Not a single flower was produced in any of the control cultures.

No plants of *Spirodela*, *Wolffia* or *Wolffiella* were thrown into flowering. Vegetative growth of all of the species was almost or completely checked. None of the plants except those of *Spirodela* was visibly affected by the ultra-violet rays. These were usually rather severely burned by the rays in all except those given the 8-minute treatment. The burned plants seemed damaged only on the upper surface. They became heavily pigmented, shriveled and gradually died but were rapidly rejuvinated by the production of vigorous normal plants. All of the L. *cyclostasa* plants producing flowers were small, pale green, decidedly unsymmetrical and with short roots.

The records of each culture are as follows:

	First Flowers Produced	Approximate Percent of Plants Flowering
1. 8-MINUTE ULTRA-VIOLET TREATMENT		
L. minor	5-4-29	15
L. m. var. *purpureus*	5-2-29	20
L. trisulca	5-2-29	10
L. cyclostasa	5-6-29	3
2. 16-MINUTE TREATMENT		
L. minor	5-3-29	30
L. m. var. *purpureus*	5-2-29	25
L. trisulca	5-2-29	15
L. cyclostasa	5-5-29	2
3. 27-MINUTE TREATMENT		
L. minor	5-4-29	20
L. m. var. *purpureus*	5-4-29	25
L. trisulca	5-3-29	15
L. cyclostasa	5-5-29	10
4. 39-MINUTE TREATMENT		
L. minor	5-4-29	15
L. m. var. *purpureus*	5-5-29	30
L. trisulca	5-4-29	15
L. cyclostasa	5-5-29	10

	First Flowers Produced	Approximate Percent of Plants Flowering
5. 51-MINUTE TREATMENT		
L. minor	5-5-29	10
L. m. var. *purpureus*	5-5-29	30
L. trisulca	5-4-29	5
L. cyclostasa	5-8-29	15
6. 63-MINUTE TREATMENT		
L. minor	5-4-29	10
L. m. var. *purpureus*	5-5-29	50
L. trisulca	5-5-29	55
L. cyclostasa	5-8-29	5
7. 75-MINUTE TREATMENT		
L. minor	5-3-29	5
L. m. var. *purpureus*	5-5-29	30
L. trisulca	5-6-29	5
L. cyclostasa	5-8-29	10
8. 87-MINUTE TREATMENT		
L. minor	5-6-29	2
L. m. var. *purpureus*	5-6-29	10
L. trisulca	5-8-29	3
L. cyclostasa	5-7-29	5

Additional Experiments with Ultra-violet Treatments.

On March 25, 1930, the foregoing experiments with ultra-violet light treatments of duckweed plants were repeated. The same species were used and one other in addition, *Lemna minima* Phillipi, a species not recorded for Ohio. This time the plants were placed 38 centimeters from the light source of the mercury quartz vapor lamp, and by measurement received 86 milliampers on slit No. 3 or 105 ergs per second per square millimeter of area. Treatments of 3, 5, 10, 15, 20 and 25 minutes were used. No attempt to measure or determine the exact quality of the light used was made but the rays proved to be much more destructive than those used in 1929.

The table below illustrates the amount of visible injury to plants in each case:

	Length of Treatment in Minutes					
	3′	5′	10′	15′	20′	25′
Spirodela polyrhiza	Slight effect	Slightly burned	Much burned	Much burned peeled	Very much burned peeled	Very much burned peeled
Lemna minor	No effect	No effect	No effect	Some burned	Burned pale	Epidermis peeled
L. minor var. *purpureus*	No effect	No effect	Slight effect	Some burned	Much burned	Burned and peeled
L. trisulca	No effect	No effect	No effect	No effect	Some browned	Much browned
L. cyclostasa	Slight effect	Slightly browned	Browned	Well browned	Much browned	Very much browned
L. minima	No effect	Slight effect	Slightly browned	Browned	Well browned	Much browned
Wolffia columbiana	No effect	No effect	No effect	Slightly browned	Slightly browned	Burned browned
W. punctata	No effect	Slightly browned	Slightly browned	Browned	Much browned	Browned burned
Wolffiella floridana	No effect	No effect	No effect	Slight effect	Slightly browned	Browned

Plants of *Spirodela* receiving 3 or 5 minute treatments continued growth without any flower production. Plants receiving 10, 15, 20 and 25 minute treatments had most of the cells of the upper parts killed. These plants were quickly replaced by budding of new plants from the treated ones, resulting in stimulated vegetative growth, just opposite to the results desired. It is interesting to note that the submerged species were not so severely effected by the light treatments. In the longer treatments, a number of the plants of each species died. Flower production following treatment was very similar to the results obtained during the 1929 experiments except that the percentage of plants producing flowers was less and also the amount of flower production did not always seem to have any definite relation to the length of light treatment received. As before, not a single flower was produced in the untreated cultures. Two additional species produced flowers in the treated cultures.

Spirodela polyrhiza, *Wolffia punctata* and *Wolffiella floridana* failed to produce any flowers. In *Lemna minor* and L. m. var. *purpureus*, from 5 to 20% of the plants receiving 10, 15 and 20 minute treatments produced flowers. In *Lemna cyclostasa*, 1 to 3% of the plants receiving the 5, 10 and 15 minute treatments flowered. In L. *minima*, three plants receiving the 10-minute treatment produced imperfectly developed flowers. Two plants of W. *columbiana* receiving the 15-minute treatment flowered, the first flowers known to have been produced by the species except in very rare instances by plants growing under natural conditions. This species is credited with the distinction of being the smallest flowering plant in the world.

Summary.

1. A review is made of the known occurrences and frequency of flower production under natural conditions in the various species of Lemnaceae.

2. A report is given of observations made upon several Ohio species found flowering under natural conditions.

3. A summary is made of a series of experiments in which treatment was made to induce flower production, through the control of various environmental factors.

4. *Lemna minor*, L.m. var. *purpureus*, L. *trisulca*, L. *minima*, L. *cyclostasa* and *Wolffia columbiana* produced flowers following ultra-violet light treatments. The first three named

also produced flowers following chemical treatment with sodium hydroxyde. No flowers were produced by control cultures in either case.

5. A list is presented of the conditions thought necessary for flower production in the family.

6. Photographs and microphotographs of the minute flowers of two species are presented to show the detailed structure of these parts.

LITERATURE CITED.

(1) **Austin, C. F.** 1870. *Wolffia columbiana.* Bull. Torrey Club 1: 36.

(2a) **Blodgett, F. H.** 1914. Development of the embryo and germination in *Lemna perpusilla.* Science 39: 292.

(2b) ———. 1923. The embryo of *Lemna.* Am. Jour. Bot. 10: 336–342. Pl 28, f. 1.

(3) **Bravo, Helio.** 1930. Les Lemnaceas del Valle de Mexico. Anales del Instituto de Biologia. Tomo I, Numero I, pp. 7–32, f. 27.

(4) **Brongniart, A.** 1933. Notes sur la structure du fruit des *Lemna.* Arch. de Botanique, 2: 97–104. Pl. 12.

(5) **Caldwell, O. W.** 1899. On the life history of *Lemna minor.* Bot. Gaz. 27: 37–66, f, 1–59.

(6) **Dalgliesh, J. G.** 1926. Observations on the British Lemnaceae. Jour. Bot. Brit. & For. 64: 48–50.

(7) **Delf, E. Marion.** 1928. The influence of ultra-violet light on plants Biol. Rev. & Biol. Proc. Camb. Phila. Soc. 3: 261–269

(8) **Delf, Ritson** and **Westbrook.** 1929. The effect on plants of radiation from a quartz mercury vapor lamp. Biol. Abstr. Sept.-Nov., 1929

(9) **Ehrhart, F.** 1779. Wiedergefundene Blute der dicken Wasserlinsen (*Lemna gibba* L.) Hannoverisches Magazin 17: 1057–1068. (Reprinted in Ehrhart's Beitrage zur Naturkunde 1: 43–51. 1787.)

(10) **Eltinger, Ethel Taber.** 1928. The effect of ultra-violet radiation upon higher plants. Ann. Mo. Bot. Gard. 15 (2): 169–240. Pl. 13.

(11a) **Engelmann, G.** 1870. *Spirodela.* Bull. Torr. Bot. Club, 2: 46–47.

(11b) ———. 1871a. Note. Bull. Torrey Bot. Club, 2: 34–35.

(11c) ———. 1871b. *Spirodela polyrhiza.* Bull. Torrey Club, 2: 46–47.

(12) **Franchet, A.** 1864. Note sur le mode de reproduction de la *Bruniera vivipara* (*Lemna arrhiza* L.) Billotia 1: 25–31, pl. 1.

(13a) **Gillman, H.** 1871a. *Lemna trisulca* in flower. Am. Nat. 5: 651–652.

(13b) ———. 1871b. *Lemna polyrrhiza* in flower. Am. Nat. 5: 652–653.

(13c) ———. 1881. *Lemna polyrrhiza* again discovered in flower on Detroit River. Am. Nat. 15: 896–897.

(14) **Goebel, K.** 1921. Zur Organographie der Lemnaceen. Flora 114: 278–305, f. 1–12.

(14a) **Griffith, W.** 1851a. Notulae ad plantas asiaticas, 3: 216, 220, 221. Calcutta.

(14b) ———. 1851b. Icones plantarum asiaticarum, 3: 264, f. 13, 16. Calcutta.

(15a) **Hegelmaier, F.** 1865. Lemnacearum a cl. Fr. Welwitsch in Africae aequinoctialia territorio angolensi collectarum descriptio. Jour. Bot. 3: 110–115. Pl. 29.

(15b) ——— 1868. Die Lemnaceen, eine monographische Untersuchung, pp. 1–169. Pl. 1–16. Leipzig.

(15c) ———. 1871. Ueber die Fructifikationstheile von *Spirodela.* Bot. Zeit. 29: 621–629, 645–666, pl. 7.

(15d) ———. 1878. Lemnaceae. Martius, C. R. P. de. Flora Brasiliensis, 3: 1–24, pl. 1. (Review in Bot. Zeit 38: 400–401. 1880.)

(15e) ———. 1895. Systematische Ubersicht der Lemnaceen. Bot. Jahrb. 21: 268–305.

(16) **Hicks, Lawrence E.** 1930. Physiological Experiments with the Lemnaceae. Proc. Ohio Acad. Sci. 8: 393–394.
(17) **Hoffman, J. F.** 1840. Materiaux pour servir a la connaissance du *Lemna arrhiza* avec quelques observations sur les autres especes de ce genre. Ann. Sci. Nat. Bot. II, 14: 223–242, pl. 1–3.
(18) **Jacobi, George.** 1930. Action of ultra-violet on germination and growth. Biol. Abstr., Jan., 1930, p. 55.
(19) **Kelberlah, A.** 1895. Das Bluhen der Wasserlinsen. Zeitschr. Naturw. 68: 136–138.
(20) **Karsten, H.** 1865. Ueber die Geschlechtsthatigkeit der Pflanzen. Bot. Untersuch. Pkys. Lab. Berlin 1: 84–112. F. 1–13.
(21) **Kurz, S.** 1865. Enumeration of Indian Lemnaceae. Jour. Linn. Soc. Bot. 9: 264–268, pl. 5.
(22a) **Leggett, W. H.** 1870a. *Lemna* Bull. Torrey Club, 1: 29.
(22b) ———. 1870b. *Spirodela.* Bull. Torrey Club, 1: 37–38.
(23) **Linnaeus, C.** 1763. Species plantarum. Ed. 2, pp. 1376–1377.
(24a) **Ludwig, F.** 1881. Über die Bestaubungsverhaltnisse einiger Susswasserpflanzen und ihre Anpassungen an das Wasser und gewisse wasserbewohnende Insekten. Kosmos 10: 7–12, f. 1–17. (Abstract in Bot. Centralbl. 8: 295. 1881.)
(24b) ———. 1909. **Kirchner, O. von; Loew, E.; Schroter, C.** Lemnaceae. Lebensgeschichte der Blutenpflanzen Mitteleuropas. 13: 57–80, f. 30–52. (Also in Archiv. f. Hydrobiologie u. Planktonkunde, 5. 15–46, f. 1–23. 1909.)
(25) **Micheli, P. A.** 1729. Nova plantarum genera. Florentiae.
(26) **Palisot de Beauvois, A. M. F. J.** 1816. Memoire sur les *Lemna,* ou lentilles d'eau, sur leur fructification et sur la germination de leurs graines. Jour. Phys Chim. and Hist. Nat. 82: 101–115, f, 1–23.
(27) **Richard, L. C.** 1833. Reliquiae Richardianae ad analysin botanicam spectantes. Nayadeae. Archives de Botanique, 1: 200–210.
(28a) **Rostowzew, S. I.** 1901. Ueber das Bluhen der Wasserlinse bei Moskau. Ann. de l'Inst. Agronomique de Moscou, 7: 63–70. (Russian.)
(28b) ———. 1905. Zur Biologie und Morphologie der Wasserlinsen. Ann. Inst. Agron. Moscou, II: 222–329, f. 1–37, Pl. 1–9. (Russian.)
(29) **Saeger, A.** 1929. The flowering of Lemnaceae. Bull. Torrey Bot. Club, 56: 351–358, pl. 17–19.
(30) **Schleiden, M. J.** 1839. Prodromus monographiae Lemacearum oder conspectus generum atque specierum. Linnaea 13: 385–392.
(31) **Thompson, C. H.** 1898. A revision of the American Lemnaceae occurring north of Mexico. Pep. Mo. Bot. Gard. 9: 1–42, pl. 1–4.
(32) **Torrey, J.** 1843. A flora of the state of New York. Vol. 2. Albany
(33) **Trelease, W.** 1882. On the structures which favor cross-fertilization in several plants. Proc. Boston Soc. Nat. Hist. 21: 410–440, pl. 6–8
(34a) **Vuyck, L.** 1895a. Over het bloeien van *Lemna.* Botanisch Jaarboek, 7: 60–72.
(34b) ———. 1895b. Sur la floraison de quelques especes de *Lemna.* Nederlandsch Kruidkundig Archief II. 6: 755–756.
(35) **Weddell, H. A.** 1849 Observations sur une espece nouvelle du genre *Wolffia* (lemnacees). Ann. Sci. Nat. Bot. III. 12: 155–171, pl. 8.
(36) **Wiggers, F. H.** 1780. Primitiae florae Holsaticae. Kiliae.
(37) **Willdenow, C. L.** 1805. Caroli a Linne Species plantarum. Ed. 4, Vol. 4. Berolini.
(38) **Wilson, W.** 1830. *Lemna gibba.* Remarks on the structure and germination. Hooker Bot. Miscellany 1: 145–149, pl. 42.
(39) **Wolff, J. F.** 1801. Commentatio de *Lemna.* 32 p. Ipl. Altdorfii et Norimbergae. (D. C. Extrait d'une dissertation sur les Lenticules par M. J. F. Wolff. Bull. des Sci. Soc. Philomath. Paris 3 (79): 142–143, pl. 18, f. 2, a-z. 1804.)

EXPLANATION OF PLATES.

PLATE I.

Vegetative and flowering plants of *Lemna trisulca* L. Ivy-joined or Star Duckweed, produced following experimental treatments.

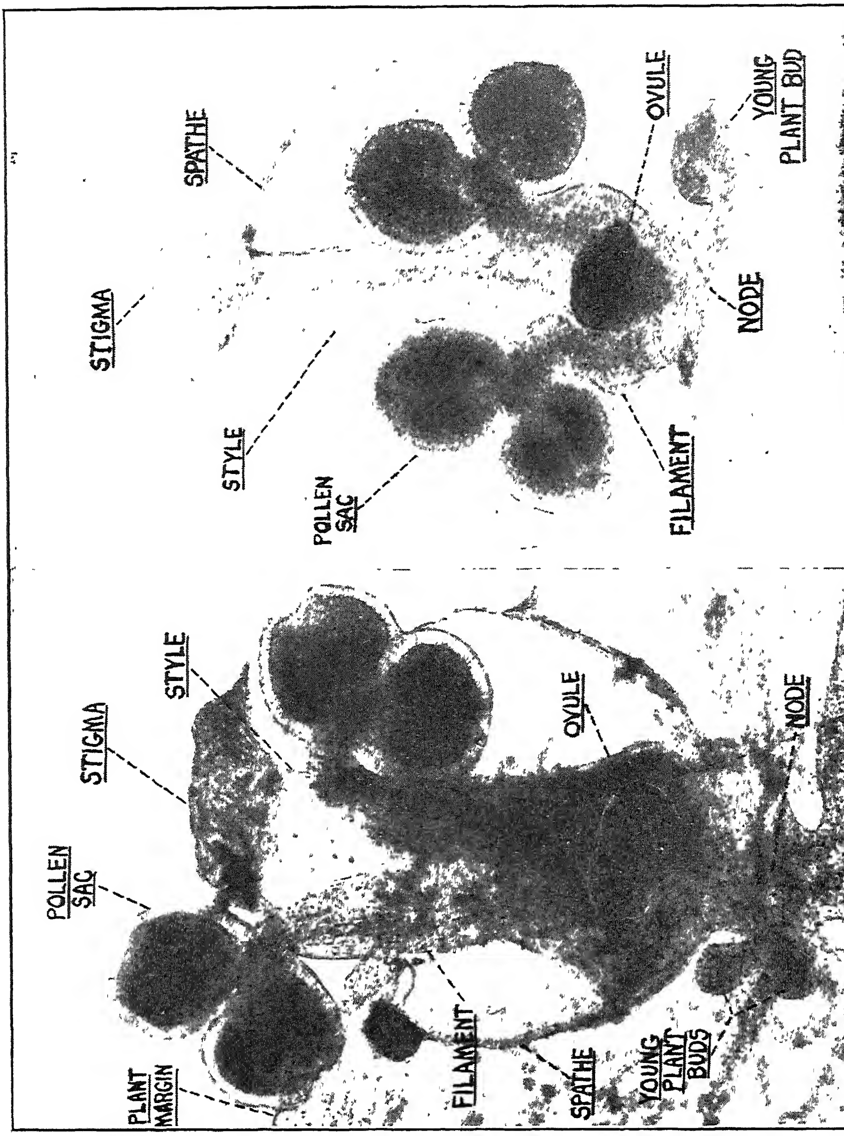
(a) Vegetative plants shown around the margins of the photograph are of the submerged type, being compact in structure and of about the same density as the water medium. The plants are flat, oblong-lanceolate in shape and connected with long internodes, many generations remaining attached forming tangled masses. This growth form is dark green in color, somewhat unsymmetrical in shape with finely serrate margins and usually an acute apex, does not have developed stomata or papules and produces long roots attached at the nodes. Magnification about 3×.

(b) Flowering, floating plants found attached in groups of 3 or 4, (center of photograph). These floating plants are produced by abscission from the submerged vegetative form. They are much smaller and are convexly curved, have very short internodes, are light green in color and decidedly cavernous, having a density of less than one, and develop stomata, but fail to produce roots. Usually one or two of the floating plants of each group produce flowers. The flowers develop from the node, growing out through the plant body, and are monecious, consisting of two stamens with two pollen sacs in each anther and a single flask-shaped pistil, enclosed in a spathe. The anthers are commonly covered with a drop of clear glandular secretion until the opening of the pollen sac.

PLATE II.

(a) Left. Microphotograph of a single flower of *L. trisulca* L. showing the spathe, the two stamens with two pollen sacs each and the single flask-shaped pistil. Magnification about 100×.

(b) Right. A flower of *L. minor* L. illustrating the same structures. Note the difference in shape of the spathe pouch in the two species. Magnification about 90×.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THE RELATION OF THE ANT, POGONOMYRMEX OCCIDENTALIS CR., TO ITS HABITAT*

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INTRODUCTION

In spite of the obvious abundance of colonies of *P. occidentalis* in the western section of the United States, our knowledge of the species is somewhat limited. McCook (2) has written quite extensively on this ant and Wheeler (3) has added many bits of valuable information. It is hoped that the following data will bring a clearer interpretation of the species *occidentalis* to those interested, especially as to the relationships existing between the ant and surrounding vegetation.

GEOGRAPHICAL DISTRIBUTION

Pogonomyrmex occidentalis is widely distributed over the far western states with the exception of California, western Oregon and Washington. It is especially abundant in Idaho, Nevada, Utah and Wyoming and generally follows the area of the desert-shrub formation. In Oregon it becomes more scarce with westward progression and I was unable to find it in the western portion of the State. In California it is replaced chiefly by *P. californicus*, especially in the San Joaquin and Imperial Valleys and the Mojave Desert. In Arizona I found it abounding from the Grand Canyon northward. Wheeler (3, p. 565) lists it from Wyoming, Colorado, New Mexico and Arizona; McCook (2, p. 125) from Wyoming, Colorado, New Mexico, Arizona, Utah, Nebraska and Kansas. I have observed it at the following specific localities:

Idaho.—Twin Falls, Rogerson, Pocatello, Nampa, Boise, Blackfoot, Arco, Idaho Falls, Wieser, Mountain Home, Shoshone, Ketchum, Hailey, Redfish Lake, Hagerman, Hammett, American Falls, Dubois, Hollister, Shoshone Falls, Shoshone Canyon, Rock Creek Canyon, Malta, Bliss and Craters of the Moon National Monument.

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Oregon.—Echo, Pendleton, Ontario, Baker and La Grande.

Utah.—Salt Lake City, Delle, Tooele, Grantsville, Snowville, Brigham, Ogden, Zion National Park and Kanab.

Arizona.—Grand Canyon, Williams, Cameron and Lee's Ferry.

Wyoming.—Cheyenne, Laramie, Rawlins, Rock Springs, Green River, Kemmerer, Cody and Ten Sleep.

South Dakota.—Rapid City, Mitchell and Sioux Falls.

Other localities from which *occidentalis* has been reported are as follows:*

Parma, Idaho; 8–29–27; G. W. Haug.
Virginia, Idaho; 7–30–37; G. W. Haug.
Stockton, Kansas; 7–15–20; R. C. Smith.
Custer County, Montana; 7–31–29; R. E. Hutchins.
Woods County, Oklahoma; 7–3–30; R. D. Bird.
Capa, Mobridge, and Newell, South Dakota; H. C. Severin.
Keremeos, B. C.; E. R. Buckell.
Oliver, B. C.; E. R. Buckell.
Okanagan Falls, B. C.; E. R. Buckell.
Osoyoos, B. C.; E. R. Buckell.
Trinidad, Colorado; W. M. Wheeler.
Ash Fort, Arizona; W. M. Wheeler.
Grants, Utah; September, 1917; R. C. Shannon.

McCook (2, p. 126) states that "the vertical distribution of *occidentalis* is probably not much above the altitude of 6,300 feet, which is the height above sea level of the Garden of the Gods," where he studied its habits most closely. Although I have often found the ant above McCook's level, the mounds are always scattered and few in number. This vertical distribution is essentially the same as northward distribution inasmuch as the limiting factors are practically the same in both cases.

STRUCTURE OF THE MOUND

External Structure—Most mounds of *occidentalis* are irregularly conical in outline. McCook (2, p. 127) speaks of them as "elliptical cones," whose shorter faces are about one-half the length of the longer faces. Wheeler (3, p. 291) refers to them as "masonry domes." As a rule the base of the mound is of greater dimensions than the slopes, or faces, but occasionally mounds are to be found with the dimensions very nearly equal. The diameter of the base is usually significant of the size of the colony, but such is not always the rule. Weaker colonies sometimes inhabit larger mounds than those of stronger and more active relatives.

*From the files of M. R. Smith.

Mounds of *occidentalis*, though primarily existing on somewhat level sandy or gravelly areas and exposed to the direct rays of the sun (Fig. 1), are often found on the tops of flat

FIGURE 1. Typical mound of *P. occidentalis* in Western Wyoming, with small crater of *Dorymyrmex pyramicus* in the denuded area. (Original).

FIGURE 2. Pebble mound of *occidentalis* on rock near Twin Falls, Idaho. Note the nest entrance at the base of the mound. (Original).

rocks (Fig. 2), around rocks and around plants (Fig. 3). Rccks often compose part of the base of a mound and upon removing them the various nest chambers and galleries are brought into view (Fig. 4). The composition of the mounds differs greatly and consists of the following chief types:

Average or typical mounds

1. Pebble mounds.
    a. Large pebbles. (Fig. 3).
    b. Small pebbles. (Fig. 2).
2. Sand mounds.
    a. Fine sand. (Fig. 1).
    b. Coarse sand (small pebbles).
3. Earth mounds.
    a. Packed earth.
    b. Loose earth.

Combination mounds

4. Earth and pebbles.
5. Earth and sand.
6. .Pebbles and detritus. (Fig. 5).
7. Earth and detritus.

Divergent types of mounds

8. Cinders.
9. Horse or cow dung (dry).
10. Bits of glass and pebbles.

The composition of the mound coverings may be classified as follows:

1. Cinder covering.
2. Frass covering (from harvested seeds).
3. Covering of bits of glass.
4. Covering of twigs or bark.
5. Covering of leaves.
6. Covering of dry horse or cow dung.
7. Covering of sheep, lizard or rabbit dung pellets.
8. Covering of keys from trees (especially ash).

Wheeler (3, p. 202) states that "* * * in *P. occidentalis* the single entrance is situated at the base (of the mound) and almost invariably on the southern or eastern side." Upon examining five hundred mounds in the state of Idaho I obtained the following data:

Number of mounds with one opening	387
Number of mounds with two openings	109
Number of mounds with three openings	4
Number of mounds with opening(s) at base	486
Number of mounds with opening(s) at top	14

Number of mounds with opening(s) on south face	126
Number of mounds with opening(s) on east face	197
Number of mounds with opening(s) on north face	152
Number of mounds with opening(s) on west face	25

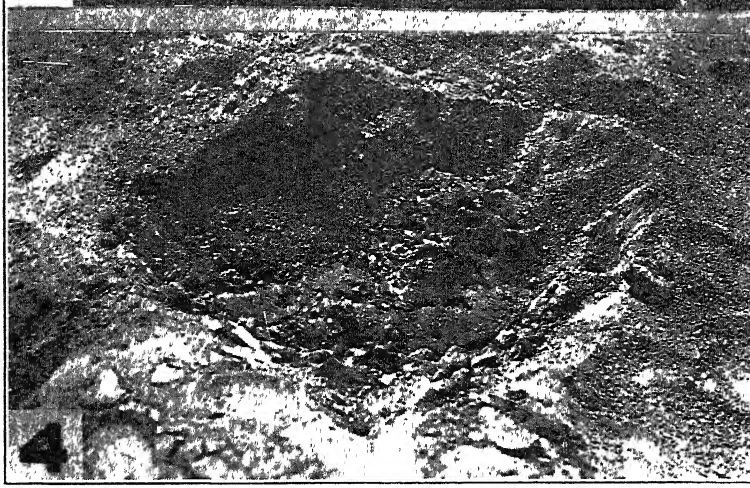

FIGURE 3. Incipient mound of large, limestone gravel around alfalfa plant near Twin Falls. The bordering vegetation is *Salsola pestifer*. (Original).

FIGURE 4. View of nest chambers of *occidentalis* under rock at base of mound. The white areas are termite galleries. (Original).

The size and shape of the nest openings vary greatly. Some are merely circular holes while others consist of several layers of packed material, giving them a "shelled" appearance.

McCook (2, p. 134) presents excellent descriptions of these openings, or "gates" as he terms them.

For further evidence as to the plasticity of *occidentalis* mound structure I offer the following data. A pebble mound was excavated for the purpose of collecting seeds from the various chambers both in the mound and below the ground level. At the end of six days, upon revisiting the mound, I found that it had been partially rebuilt. The only major difference between the rebuilt mound and the original architecture was the presence of two entrances, one on the east face and one on the west, whereas originally there was only one entrance and that on the southeast face.

Mounds of *occidentalis* do not always occur singly. There are many double mounds and occasionally a triple one. I have never observed more than three mounds within the same denuded area.

Internal structure—The position and numbers of the nest chambers are especially interesting (Fig. 4). The *brood chambers* vary in number and size according to the relative strength of the colonies. Invariably there are present one or more chambers near the surface of the mound where the brood is isolated during the day time (providing the temperature is not too high) and chambers at the base of the mound or under the ground level to which the brood is moved at night or on cooler days. This movement is apparently entirely dependent on temperature fluctuations and will be discussed later. The shape of the chambers varies between colonies and within the same colony as well. The chambers are usually fairly large, averaging 8.5 centimeters, and are irregularly domed with galleries leading to the various adjacent chambers.

The *seed chambers* are especially interesting for there is stored the fruit of the ants' labor. These, like the brood chambers, also vary in number and size, but as a rule they are not abundant and are more or less slit-shaped, being noticeably longer than high. I have found as many as seven and as few as one in a single mound, some overloaded with seed and others containing very little or none. A study of the various seeds harvested has proven interesting and will be dealt with further in the paper.

I have observed many cases in which both brood and seed were confined to the same chambers but this seems to be the

exception rather than the rule. The brood, however, is rarely isolated into separate chambers according to its age but is usually intermingled in the same chambers.

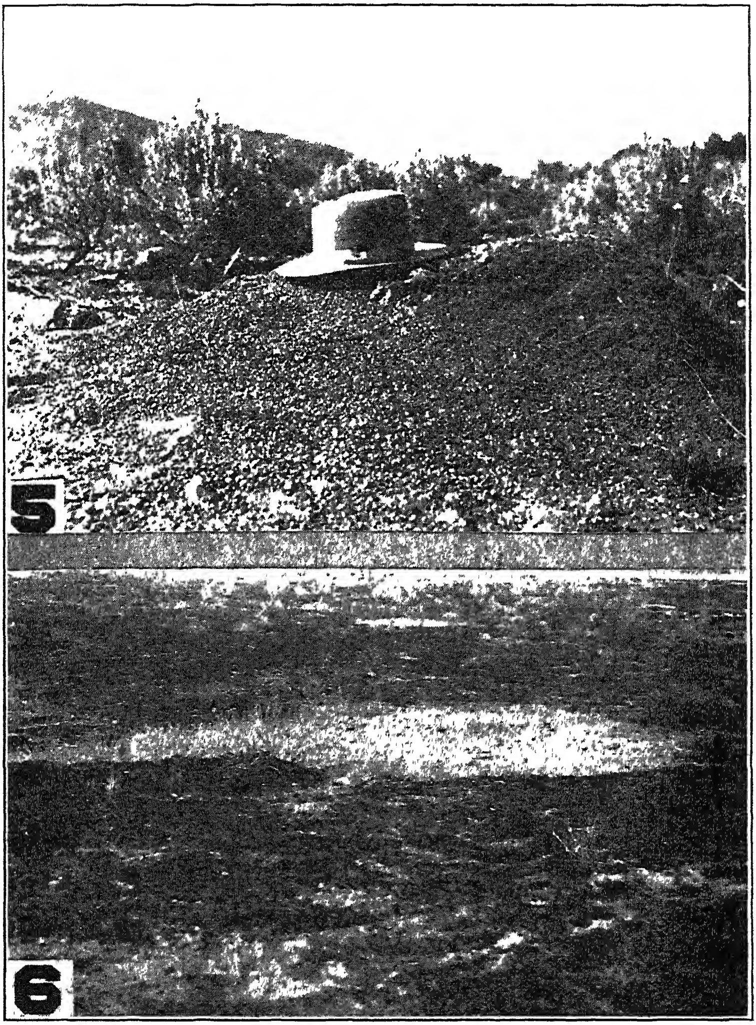

FIGURE 5. Combination mound of pebbles and detritus in an almost pure stand of sagebrush near Twin Falls. (Original).

FIGURE 6. Burned area of bromegrass and sagebrush near Ontario, Oregon, illustrating the protection of the mound by its denuded area. (Original).

Table I lists several typical mound temperatures. These temperatures, both inside and outside of the mounds, vary with atmospheric temperature and are never constant. From the data in the table we can recognize the correlation between these fluctuating temperatures and the movement of the brood. This movement is gradual as a rule, the brood being transferred from one chamber to another, the last position being the optimum for the maximum or minimum temperature concerned.

The temperature must not be too high for the delicate brood to withstand, neither must it be too low for proper incubation of the brood. Minor fluctuations are met with adjustments inside of the mound. As the temperature rises during the day, the workers move the brood from the deep recesses underground into the mound and often just under the surface covering. As the temperature decreases the brood is moved from the upper chambers and returned to the lower levels. That this process is gradual has already been pointed out.

THE DENUDED AREA

The cleared or "denuded" areas surrounding mounds of *P. occidentalis* are as impressive as the mounds themselves (Fig. 1). They represent "subseres," average about five feet in diameter and are more or less regularly circular in outline. They are due to the destruction, by the worker ants, of vegetation closely surrounding the mounds. The plants are literally "chewed-down," bit by bit, from the apex to the base. The debris is either carried away by the ants or scattered by the wind. The rate and extent of denudation is proportional to the size and strength of the colony. I carefully observed *occidentalis* workers cutting down a large plant of wild lettuce at the base of a mound. Fourteen days of cutting were required for the plant, 12.1 centimeters high, to be reduced to a mere stump of 0.2 centimeters, only a few ants working at a time. Small grasses are often hewn by the sharp mandibles of a single ant. The remaining stubble eventually dries out and is disseminated by the wind. The apparent tolerance of the ants toward some plants growing in the denuded areas cannot be explained. Peppergrass (*Lepidium sp.*) seems to be commonly tolerated in many sections.

As a rule the denuded areas are cleared of all vegetation, but occasionally there are a few scattered grasses, such as

Agropyron and Stipa, growing near the periphery of the circle. Rarely do we find plants growing on the mounds themselves. Many annuals border the denuded areas, among the most common being Russian thistle (*Salsola pestifer* A. Nels.), mustards (*Sophia parviflora* (Lam.) Standl. and *Sisymbrium altissimum* L.) and bromegrass (*Bromus tectorum* L.).

One is not certain whether the denuded area is detrimental or advantageous to the life of the colony. The strong, prevailing, westerly winds of the west tend to "hollow-out" the mounds of *occidentalis* and related species which have denuded areas surrounding their mounds. This is detrimental to the

TABLE I.

Some Typical Mound Temperatures.

Temperature of*	Mound 1	Mound 2	Mound 3	Mound 4	Mound 5	Mound 6	Mound 7
Sun	97	97	**	**	**	**	**
Shade	88	88	69	69	69	69	69
Top of mound	106	91	70	70	70.5	70	70.5
Interior of base	110	93	71	70	70	71	70.2
In entrance	105	91	70	70.5	70	70	69.5

*Temperatures in Degrees F.
**Cloudy; no sunlight.

continued existence of the colony. Such is not the case with adjacent mounds of Formica which are invariably protected by surrounding vegetation, no matter how short or scant it may be. In some localities *occidentalis* mounds are tightly packed and are composed of a material which resists the average winds to a great extent. Mounds composed of loose earth, sand or detritus are much less stable than pebble mounds for they are more inclined to be destroyed or at least damaged by the sweep of wind over the denuded areas.

Of what value is the denuded area? Near Ontario, Oregon, I observed a large sagebrush-bromegrass area which had been burned-over, completely destroying the vegetation and amplifying the preponderance of *occidentalis* mounds (Fig. 6). The large denuded areas surrounding the mounds had prevented the fire from coming into direct contact with them. That there was a slight mortality of the ants is obvious, but had there been no denuded areas, the destruction of at least a large portion of the colonies would have been inevitable.

Occasionally *occidentalis* mounds do not have denuded areas. I observed full-sized mounds in large patches of annuals where the vegetation all but touched the sides. I observed two colonies in a huge area of *Bromus tectorum* L. (Bromegrass) which made no effort to clear areas around the mounds. Ants returning to the colony would continually weave to and fro, dodging stems of Bromus and often temporarily losing their loads of seed.

OBSERVATIONS IN THE TWIN FALLS, IDAHO AREA

"The Twin Falls Area, Idaho, is situated in the northern part of Twin Falls County. It lies in the southern part of

TABLE II.

Ecological Distribution of Occidentalis in the Twin Falls Area.

Ants Present			Ants Absent		
Vegetation			No Vegetation		Vegetation
Abundant	Intermediate	Scarce	Wet	Dry	
Sagebrush Brome grass	Greasewood	Shadscale	Lake Margins	Sand dunes Old lake beds Plowed areas	Cultivated fields

the great inter-mountain valley known as the Snake River Plains." (1) Thus it forms a part of the Upper Sonoran Zone with its characteristic fauna and flora. The Twin Falls area covers approximately 350 square miles, or 223,360 acres.

"The climate of the area, like that of the greater part of the Snake River Plains, is characterized by a low annual rainfall, a dry atmosphere, hot summers, cold winters, and a large proportion of sunny days." (1) The average annual precipitation at Twin Falls is about 11.03 inches and the average annual snowfall 27.5 inches at the same locality.

In the Twin Falls area mounds of *occidentalis* are present only where there is vegetation. They are very abundant in greasewood communities, and occasional in regions of shadscale. However, we do not find them in all vegetational areas.

In cultivated fields, where the soil is periodically disturbed, they are not present. Nor are they abundant in very wet tracts bordering streams where there is likely to be a luxuriant growth of plants. Colonies do not exist on active sand dunes nor on the old dry lake-beds. Plowed areas only support mounds when they are undisturbed for some time and until plants begin to grow. Table II summarizes these various points.

Occidentalis brood will not mature in soils of high mositure content. Excessive moisture germinates the seeds stored by the workers, making them utterly useless for food. After a shower, under normal circumstances, when the seeds become

TABLE III.*

DISTRIBUTION IN RELATION TO THE VEGETATION IN THE TWIN FALLS AREA.

PLANT COMMUNITY	LOCALITY	NUMBER MOUNDS IN ONE-TENTH SQUARE MILE		
		Established	Incipient	Abandoned
Sage-rabbitbrush.....	Twin Falls	6	5	0
Sage-brome grass.....	Twin Falls.......	8	4	0
Sagebrush...........	Twin Falls.	7	2	0
Sage-greasewood.....	Hagerman..... .	6	4	0
Greasewood	Hagerman.......	4	5	0
Greasewood-Shad ...	Hammett	3	4	0
Shadscale............	Hammett	0	2	0
Brome grass	Twin Falls.......	11	9	1

*The figures given are the means of three counts.

damp, the workers transport them to the surface of the mound where they are able to thoroughly dry. They are then returned to the seed chambers. In an area of very high humidity, if the seeds are taken to the surface to dry, they germinate instead. This is detrimental and may lead to the extinction of the colony. The result is the same when rain falls on the exposed seeds before the workers are able to carry them into the interior of the mound. Thus we occasionally observed sparse growths of annuals on the mounds themselves. The rarity of this occurrence has been pointed out in a preceding paragraph.

The relative distribution of *occidentalis* in regards to the vegetation is illustrated in Table III. Sagebrush and brome-grass areas support the greater number of colonies and shadscale communities the least. The abundance of mounds in the

bromegrass areas is explained by the harvesting habits of the ants, *Bromus tectorum* seeds being the chief seeds harvested.

Mounds of *occidentalis* are found on all types of soil in the Twin Falls area but occur most abundantly on gravelly soils. Perhaps this is due to the apparent preference for pebble mounds in many localities. Portneuf silt loam of wind-blown origin covers about 83% of the Twin Falls area (1). Table IV lists the types of soils present and the abundance of *occidentalis* mounds in these various soil areas.

TABLE IV.*

DISTRIBUTION OF MOUNDS ON VARIOUS SOILS IN THE TWIN FALLS AREA.

SOIL	LOCALITY	NUMBER MOUNDS TO ONE-TENTH SQUARE MILE
Portneuf silt loam	Twin Falls	22
Rough stony land	Twin Falls	24
Portneuf silt loam (Shallow phase)	Buhl	18
Portneuf silt loam	Castleford	22
Downey loam	Clear Lakes	7
Rough stony land	Rock Creek	26
Downey loam	Rock Creek	12
Rough stony land	Shoshone Falls	28

*See literature cited, (1).

HARVESTING HABITS

That *occidentalis* is graniverous is evidenced by the presence of seeds in many of the nest chambers. According to Wheeler (3, p. 282) *occidentalis* is one of the most characteristic of the American harvesting ants. Table V illustrates the many species of seeds found in various mounds. Seeds of *Bromus tectorum* were predominant, due to the wide expanse of this plant in Idaho.

May seeds which are present in the nest chambers do not abound in the surrounding area and are often at a considerable distance from the colony. From one mound I excavated several wheat seeds, while the nearest wheat field was two miles distant. It is possible, but not probable, that a few isolated wheat plants were growing in a nearby meadow and that these were harvested by the ants. From observations it is evident that seeds of sunflowers, thistles and other annuals have been transported great distances by the ants. In one

case the nearest sunflowers were 0.7 mile from a group of mounds, Canada Thistle, 0.4 mile, Alfalfa 1.35 miles, and Jim Hill mustard 0.25 mile. Long lines of workers were transporting the above seeds to their formicaries. The seed chambers of mounds in dense bromegrass areas often contain a greater quantity of other seeds and only a few colonies were located

TABLE V.

SEEDS HARVESTED IN THE TWIN FALLS AREA.

SEED	ABUNDANCE
Carduus arvensis L. Robs	Abundant
Carduus lanceolatus L	Abundant
Bromus tectorum L	Very abundant
Agropyron repens (L.) Beauv	Abundant
Agropyron spicatum Scribn. & Sm.	Moderately abundant
Lupine sp.	Scarce
Salsola pestifer A. Nels	Very abundant
Sisymbrium altissimum L	Moderately abundant
Sophia parviflora (Lam.) Standl	Moderately abundant
Sophia longipedicellata (Fourn.) Howell	Scarce
Melilotus alba Desv	Moderately abundant
Medicago lupulina L	Scarce
Ambrosia trifida L	Scarce
Ambrosia artemisiaefolia L	Scarce
Bursa bursa-pastoris L	Scarce
Thlaspi avense L	Scarce
Lychvis alba Mill	Scarce
Amaranthus retroflexus L	Scarce
Chenopodium album L	Moderately abundant
Polygonium persicaria L	Scarce
Rumex acetosella L	Scarce
Avena fatua L	Moderately abundant
Hordeum jubatum L	Abundant
Lactuca scariola L	Scarce
Chaetochloa viridis L. Nash	Scarce
Sonchus arvensis L	Scarce
Iva axillaris Pursh	Scarce
Atriplex rosea L	Abundant
Helianthus annuus L	Moderately abundant

which seemed to harvest bromegrass seeds exclusively. It is safe to state, however, that seeds of bromegrass are more generally harvested than others especially in the Twin Falls area. This is due primarily to the predominence of *Bromus tectorum* in the semi-desert areas.

COMPOUND NESTS

One of the most interesting associations of *P. occidentalis* is its relationship to other ants, either intermingled with the

colony or existing in separate nests on or in the mounds or on the denuded areas. I observed several mounds in western Wyoming which supported small crater-mounds of *Dorymyrmex pyramicus* on the faces and on the surrounding denuded areas as well. (Fig. 1). Wheeler (3, p. 426) lists the genera Dorymyrmex and Forelius as compoundly associated with *occidentalis*. McCook (2, p. 155) lists *Formica sanguinea*, *Dorymyrmex insanus* (*pyramicus*) Buckley and *Dorymyrmes flavus* McCook.

In the Painted Desert of Arizona I observed several mounds of *occidentalis* which supported small craters of *Lasius niger* var. in their denuded areas. There is no apparent relationship between the two species except the tolerance for one another. There were apparently no connecting galleries and the individuals of the Lasius colonies were not found walking on the mounds. Such compound nests are apparently rare in Idaho.

McCook (2, p. 152) mentions *Termes flavipes* as associated with *occidentalis*. I, too, have noticed this relationship, and in a large area of greasewood I found fourteen nests which contained the termites and three which did not. Their position in the nest is shown in Fig. 4.

BIBLIOGRAPHY.

1. **Baldwin, M.**, and **Young, F. O.** "Soil Survey of the Twin Falls Area." *U. S. D. A., Bur. Soils*; *Advance Sheets*—Field Operations of the Bureau of Soils, 1921; (1925). (Excellent soil map.)
2. **McCook, H. C.** The Honey Ants of the Garden of the Gods, and Occident Ants of the American Plains. J. B. Lippincott & Co., Philadelphia, 1882.
3. **Wheeler, W. M.** Ants; their Structure, Development and Behavior. Columbia Univ. Press, New York, 1926.
4. **Idem.** "The Ants of the Grand Canyon." *Bull. Amer. Mus. Nat. Hist*, XXII, (1906), 329–345.
5. **Idem.** "New Agricultural Ants from Texas". *Psyche*, IX, (1902), 387–393.
6. **Wildermuth, V. L.**, and **Davis, E. G.** "The Red Harvester Ant and how to subdue it". *U. S. D. A., Far. Bull.* 1668, 1931.

The Human Mechanism.

A new and thoroughly up to date revision of this standard text has been prepared by Dr. Waddell. The best features of the older edition have been retained, and much new material has been added. Especially have the chapters on internal secretions, vitamins, the prevention of communicable diseases, and the organs of special sense, been brought up to date. Always one of the best of the books on physiology and hygiene, the new edition appears to come up to the high standard set by the old.

The Human Mechanism, by HOUGH and SEDGWICK. Second Revised Edition, by J. A. WADDELL, M. D., xi, 681 pp. New York, Ginn and Co., 1931.

SEX IN ARISAEMA TRIPHYLLUM*

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Our common wild Jack-in-the-Pulpit (*Arisaema triphyllum* (L.) Torr.) is often referred to as a dioecious species. Gow (3), Atkinson (1), Pickett (5) and Schaffner (6), have noted, however, that a considerable number of the plants bear flowers of both sexes. While studying the Japanese Arisamea (*A. japonica*) which is morphologically close to our *A. triphyllum*, Maekawa (4) noted that the "Lighter corms are male and heavy corms are female without fail and the sexual state moves on from the asexual state to the male state and lastly reaches the female state and stays therein."

Schaffner (6, 7) and others have also shown that the sex of mature plants may be controlled by regulating the physiology of the plant, and Pickett (5) and Schaffner (6) have noted the difference in sex ratios in different habitats.

The present study has been conducted to ascertain the relation between the relative age and development of the plant and the type of flower appearing in the inflorescence.

The mature plant generally consists of one or two compound leaves and an elongated flower stalk, the aerial parts arising from a subterranean perennial corm. The flowers are borne on a spadix and are surrounded by a spathe, which is typical of all the Araceae.

Small, single-leaved, non-flowering plants commonly occur associated with the mature plants. These small plants have generally arisen from lateral buds on the parent corm. The plants originating from these "bud corms" soon become separated from the parent plant and after several years of development produce flowers. Occasional isolated individuals, or even small clumps of equal-aged plants, may be noted in areas where other plants are not abundant. It seems probable in these cases that the plant has arisen from a seed, or in the case of a clump of equal-aged plants, from the seeds of a single

*Papers from the Department of Botany, the Ohio State University, No. 293.

spadix. It is to be noted, however, that vegetative multiplication is much more common than reproduction by means of seeds.

Studies by the writer since 1925, both on marked plants in the field and in experimental plots, have shown that *Arisaema triphyllum* begins as a weak, non-flowering plant with a small corm. This is true for both the seedling plant and the plant having its origin in a vegetative off-shoot.

After several years of growth—generally more than three, depending on the habitat—the plant has its first flowers. The first inflorescence is generally small and contains only staminate or male flowers.

Since the habitat is a decided factor in the development of the individual, subsequent stages in the life history are closely linked with the environment. If the plant is in a moist, rich woods and little disturbed by animals, it increases in size from year to year, both in the aerial and subterranean parts.

In several years a few carpellate or female flowers may appear on the spadix, sometimes mixed with the staminate flowers, but generally near the base of the inflorescence. This intermediate or monoecious stage generally lasts several years, the proportion of carpellate flowers becoming greater until the whole inflorescence is made up of carpellate flowers.

It is thus apparent that in *Arisaema triphyllum* a single plant, if grown in a suitable habitat will, during its life history, run the whole gaunt of sexual expression from the immature non-flowering condition into the male and from that through varying degrees of intersexuality into a female condition. It remains thus as long as the plant is undisturbed, or does not become weakened through an over-production of side corms.

The stability of the sexual state is dependent upon the physiological condition of the individual. If the habitat is unfavorable to good growth, the plant may remain in the staminate or monoecious state indefinitely.

Schaffner (7) Maekawa (4) and others have shown that removal of the lower or storage part of the corm or a portion of the leaf surface throws the plant, in the succeeding year, into a condition similar to that occurring earlier in the life history. Specifically, if a small portion of the corm or of the leaf is removed from a mature plant bearing carpellate flowers, the plant will produce a mixed inflorescence the next year. If, however, the pruning is severe the plant may be thrown

into the staminate, or even the non-flowering condition. It is of course necessary to do this before the time of flower bud formation.

It is therefore reasonable to suppose that the basic physiology of the plant, influenced by the activity of the synthetic portion or the storage regions, directly influences the production of the different sexual types.

While no extended physiological studies have been made by the writer, certain correlations have been shown to exist between the physiology of the individual and its sexual expression.

The writer (2) has previously noted in twelve species of plants, including *Arisaema triphyllum*, that a portion of a plant bearing staminate structures has a higher catalase activity than similar structures bearing carpellate flowers. It is not intended to imply that the enzym catalase is a regulator, but rather a valuable indicator of the metabolic level of the portion of the organism studied.

A study of the activity of this enzym is relatively simple, consisting merely of measuring the amount of oxygen released from a standard quantity of hydrogen peroxide by the enzym in a given quantity of plant material. A more extended discussion of the method used has already been presented by the writer (2).

In the present study, determinations of the activity of the enzym in the expressed juice of the corms of plants bearing the various types of inflorescences were made. The plants were collected in a moist, beech woods near Westerville, Ohio, May 20, and taken into the laboratory where the determinations were made as soon as possible.

The following table (Table I) shows the results obtained from determinations on a total of 22 corms fairly evenly divided between the different types.

TABLE I.

Arisaema triphyllum.

AVERAGE FOR THE CATALASE ACTIVITY OF THE EXPRESSED JUICE OF THE CORMS. READINGS IN CC. OF GAS PRODUCED IN 5 MIN. AT 21° C.

Non-flowering	Staminate	Monoecious	Carpellate
4.3	7.2	6.4	4.8

It is thus apparent that the corms of the pure staminate plants had a higher catalase activity than those of the pure carpellate plants, while those giving rise to the monoecious or mixed inflorescences had an intermediate position. The non-flowering plants were the least active.

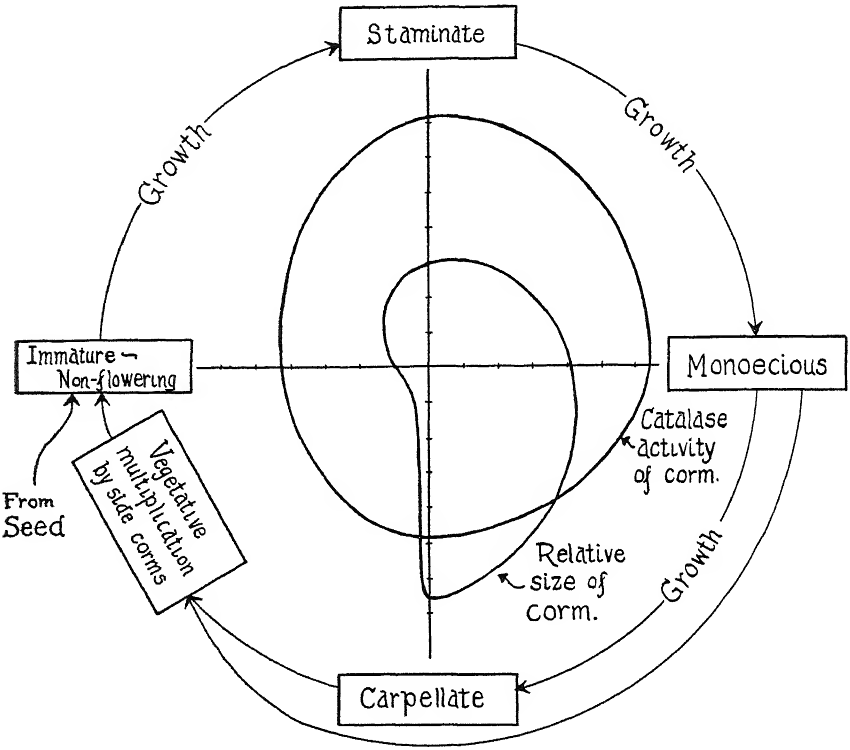

FIGURE 1. Diagram of the normal life history of *Arisaema triphyllum*, showing the relation between size and catalase activity of the corm and the sexual expression of the inflorescence.

Figure 1 is a diagram of the life history of a plant, showing the normal sequence of sexual expression, the catalase activity and relative weight of the corm.

CONCLUSIONS.

Arisaema triphyllum is not a true dioecious plant but undergoes a series of changes in the course of its life history. It arises either from a vegetative side corm or a seed as a small non-flowering individual. Later the plant produces successively

a pure staminate, next a mixed and last a pure carpellate or female inflorescence.

The sexual states are relatively unstable, being easily modified or changed by natural fluctuations in the environment or by mutilation of the vegetative parts of the plant.

Plants producing staminate flowers arise from corms characteristically light in weight and high in catalase activity, while those producing carpellate flowers are heavier with a lower catalase activity. Plants in a transitional or monoecious stage have an intermediate corm weight and catalase activity.

The type of sexual expression in *Arisaema triphyllum* is induced by the basic physiology of the vegetative parts of the plant at the time of flower bud formation.

LITERATURE CITED.

(1) **Atkinson, G. F.** Experiments on the morphology of *Arisaema triphyllum*. (Abs.) Bot. Gaz. *25:* 114. 1898.
(2) **Camp, W. H.** Catalase activity and sex in plants. Amer. Jour. Bot. **16:** 221–224. 1929.
(3) **Gow, J. E.** Observations on the morphology of the aroids. Bot. Gaz. **56:** 127–142. 1913.
(4) **Maekawa, Tokujiro.** On the phenomenon of sex transition in *Arisaema japonica* Bl. Jour. Coll. Ag., Hokkaido Imp. Univ. *12:* 217–305. 1924.
(5) **Pickett, F. L.** A contribution to our knowledge of *Arisaema triphyllum*. Mem. Torrey Bot. Club, *16:* 1–55. 1915.
(6) **Schaffner, J. H.** Control of the sexual state in *Arisaema triphyllum* and *Arisaema dracontium*. Amer. Jour. Bot. *9:* 72–78. 1922.
(7) **Schaffner, J. H.** Siamese twins of *Arisaema triphyllum* of opposite sex experimentally induced. Ohio Jour. Sci. *26:* 276–280. 1926.

Law for the Physician.

That ignorance of the law is neither a valid nor an economic excuse is a recognized principle in our every-day contacts. To the physician, who makes many more legal contacts than the average layman, this principle assumes considerable importance. The physician is made liable to action at law by nearly every professional act.

A physician well versed in legal matters has undertaken to outline the fundamentals of medical jurisprudence for his professional colleagues. Medical jurisprudence is that branch of science which shows how the law affects the practice of medicine, as opposed to legal medicine, which applies to the manner in which medical science affects the practice of law.

The volume contains chapters on the contractual relationships of physicians, witnesses and evidence, torts, property rights, physicians and criminal responsibility, and finally a very interesting chapter on physicians as lawmakers.

The book is clearly and concisely written, illustrated with abundant cases, and is designed to be of real personal service to the physician in his contacts with other people.

Medical Jurisprudence, by C. Scheffel, M. D., LL. B., XII + 313 pp., Philadelphia, P. Blakeston's Son & Co., Inc., 1931.

STUDIES IN HUMAN INHERITANCE VII HEMOPHILIA.

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Recently Birch (1931) has reported the use of the female sex hormone in the control of hemophilia. While we can not question the results of this treatment as recorded, its use is based on a fundamental misconception, to which attention should be directed. The author says "Taking into consideration that only males have the disease, while it is transmitted through the unaffected female, one is forced to the conclusion that if the female can transmit the disease, she must potentially have the disease. Then there must be something in the female mechanism which holds the disease in abeyance." Based on this assumption, ovarian extract and ovarian transplants were used as a means of control for hemophilia in man, with apparently good results.

It must first be pointed out that it is not in the least necessary to assume that because unaffected females can transmit the disease they must potentially have the disease. Such a conclusion is contrary to all genetic principles. Hemophilia is known to be a sex-linked character. Males show it with a definite frequency because only one of the pair of sex chromosomes in the male carries the factor, thus making a single dose of the factor *h* for hemophilia effective. In women, a single dose of the factor will be recessive to the normal dominant allelomorph on the other member of this pair of chromosomes. Unaffected males also have this normal dominant factor *H*. Of the women who transmit the disease, practically all, if not absolutely all, will be heterozygous, free from the symptoms because of the presence of the normal dominant allelomorph.

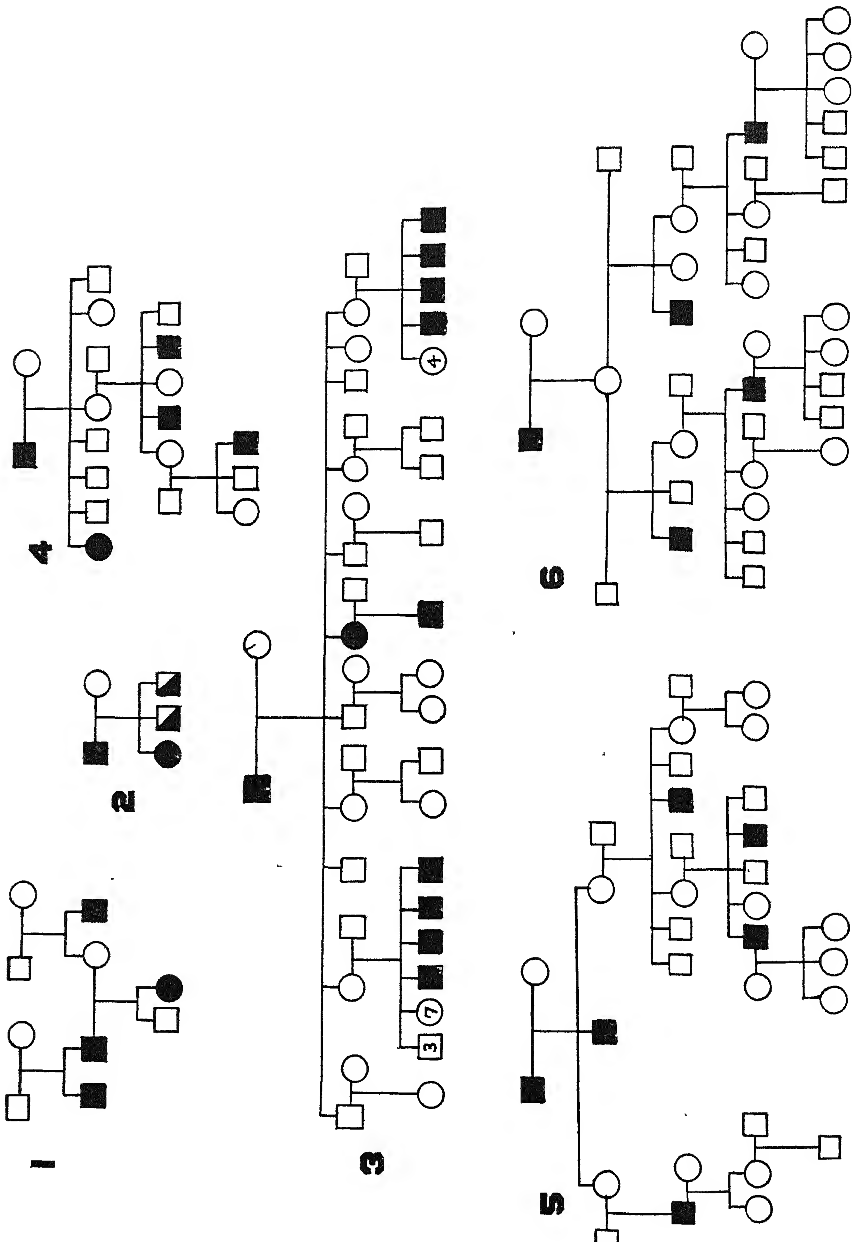
There is thus no *a priori* reason for supposing that the female sex hormone should be a specific for the control of hemophilia. It is known that injection of a foreign protein is efficacious as a control for this disease (Minot and Buckman 1927), and it would seem safer to assume that the results recorded by Birch are manifestations of a more general phenomenon, rather than to invoke a more specialized and definitely questionable hypothesis as an explanation.

The possibility exists that females receiving the double dose of the gene for hemophilia may live without manifesting symptoms of the disease. This is unlikely from a genetic standpoint, but if it were the case, Birch's hypothesis might still be tenable. This brings up again the old question as to the fate of homozygous hemophilic females. Do they exist with the symptoms of the disease? Do they exist as apparently normal individuals because of some protective mechanism? Has such a zygote ever been formed and the result recorded? Or is a double dose of the gene lethal, so that they never exist at all? Geneticists have favored the last hypothesis.

A female of the formula *hh* would only be expected to occur when a hemophilic man married a woman who was a carrier, or who was herself hemophilic. How often have matings of this sort actually occured in the pedigrees which have been recorded? In looking for such matings, it is necessary to search for instances where a hemophilic man has a hemophilic son or a hemophilic father-in-law. In such cases he might theoretically have a hemophilic daughter, since the wife would certainly be a carrier. A hemophilic brother or grandfather of the wife, even though her father were normal, would indicate that she might be a carrier.

Color-blindness, which is also a sex-linked character, presents the same requirements. To illustrate how this character can appear very occasionally in women, Fig. 1 is presented from our records.

Upon examination of 250 published pedigrees of hemophilia, the conditions under which a hemophilic woman would be expected to arise are found to be extremely rare. This is to be expected, as only 11% of hemophilic males live to be 22, and the chances of these marrying carrier females are extremely small. Only nine times in these 250 pedigrees, involving many hundreds of hemophilia males, did an alleged hemophilic man marry a known carrier. Seven of these cases are authoritatively considered by Bulloch and Fildes, who reviewed them, to be not true hemophilia at all. These are the Fischer, Weitz, Heath, Dunn III, Vanderveer, Treves and Masters families. In another instance (the Mampel family, reported in 1908 by Morawitz and Lossen), Klug (1926) has shown that several of the alleged hemophilic males did not have hemophilia, but merely said they did in order to escape military service. These included one who married a carrier. Thus this case must also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be left out of consideration. This leaves but a single published instance (the Hauser-Keller family, from Stahel, 1880) in which a known hemophilic male married a known carrier female. One hemophilic son and one normal daughter were produced, thus giving no evidence as to the possibility of hemophilic daughters.

In the 75 families recorded by Bulloch and Fildes as instances of true hemophilia, involving several hundred hemophilic men, there are found nineteen cases of alleged hemophilia in women. Of these, 15 had normal fathers, and therefore from a genetic standpoint could not have had hemophilia. The other four had hemophilic fathers, but each had at least one normal son, which could not happen if they were homozygous *hh* females. We can thus agree from a genetic viewpoint that these were not cases of hemophilia in women.

Three interesting recent pedigrees are on record in which hemophilic females are reported. In each of these cases the father is hemophilic, but there is no proof that the mother is a carrier, although she may very well be.

In the Nar family (Figure 2, after Davenport, 1930) a hemophilic man had a daughter who was diagnosed as hemophilic. She had a coagulation time of 15 minutes. She has two brothers, aged 2 and 4, who although too young to be definitely diagnosed, bleed very easily and for a long time after minor cuts, and are probably hemophilic, indicating that the mother is a true carrier.

Warde (1923) gives a pedigree involving a hemophilic woman. Her father was hemophilic, as was her only son. She suffered extremely from hemorrhage at the birth of her son,

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EXPLANATION OF FIGURES

FIGURE 1. The occurrence of color-blindness, a sex-linked character, in women. The H. family, Ohio. Similar conditions would be necessary for the appearance of hemophilia in women.

FIGURE 2. The Nar family, after Davenport. The daughter. aged 8, has been diagnosed as hemophilic. The two sons are too young to be definitely diagnosed, but bleed very easily and for a long time after cuts.

FIGURE 3. Warde's pedigree involving a hemophilic woman.

FIGURE 4. The Dorr family, after Madlener, showing alleged hemophilia in a woman.

FIGURE 5. Mc C. family, Ohio, showing conditions (second generation) under which a hemophilic female might be expected to arise. This pedigree is the second one to be published in which such conditions occur. In this case both daughters were free from the disease, but carriers.

FIGURE 6. Co. family, Ohio, showing the identical transmission of hemophilia through both lines of descent from a carrier who married twice.

as well as from other operations and minor cuts. This family is shown in Figure 3.

An interesting pedigree is given by Madlener (1928). The girl involved had subcutaneous hemorrhage from an early age, and frequently bled all day from a scratch. It has been suggested by Lenz that perhaps she was an intersex. This family is shown in Figure 4.

It is of course possible that even the cases just cited are examples of purpura or some other hemorrhagic defect, and not true hemophilia. They may be due to imperfect dominance of the normal allelomorph of the hemophilia gene. Laboratory diagnoses are unfortunately all too rare in reported cases. It is of interest to note, however, that in these three cases the father was hemophilic, and in one case the son as well, thus fulfilling the genetic requirements. It is to be hoped that adequate laboratory diagnoses may be made in these cases.

There still remains the bare possibility that potentially hemophilic females (*hh*) live as normal individuals, protected by some mechanism peculiar to the female sex. Such women, if they exist, should have all hemophilic sons, no normal ones. The fact that only one published family is found where a female of the formula *hh* would be likely to arise, makes conclusive data on this point impossible to obtain. There is no logical basis, however, for supporting such a supposition.

Among our records at the genetics laboratory of the Ohio State University are several cases worthy of note. First is a case where a hemophilic male married a carrier female, as evidenced by a hemophilic son. This is apparently only the second authentic case to be recorded. The diagnosis in this family was supported by complete laboratory examination. In the second generation of this pedigree half of the daughters might be expected to have hemophilia. The two daughters occurring here were normal, however, although both were carriers. Here again is no definite evidence for or against the possibility of the realization of a hemophilic female. This family is shown in Figure 5.

Three families in Ohio have been referred to us as containing hemophilic females. Upon laboratory diagnosis, no evidence of true hemophilia was found.

Another new pedigree of hemophilia is offered here, chosen from many in our records as showing the practically identical course of heredity through both lines of descent from a known carrier who married twice. (Figure 6).

CONCLUSIONS.

Upon the examination of 250 published pedigrees of hemophilia, only one authentic instance could be found where a known hemophilic male had married a known carrier female, and where a hemophilic daughter might therefore be expected. A second pedigree involving a mating of this sort is presented in this paper. A total of three daughters, all normal, and two hemophilic sons, result from these two matings. Examination of 22 pedigrees where hemophilic women are recorded indicates that from a genetic standpoint nineteen of them could not have had hemophilia. The other three cases, more recently described, may possibly be true hemophilia. There is therefore at hand insufficient data with which to definitely settle the question as to the fate of homozygous females. There is not the slightest evidence, however, that such women can live as normal individuals because of some protective mechanism.

Women who transmit the disease are undoubtedly all heterozygous, free from the symptoms of the disease not because of any inherent protective mechanism peculiar to their sex, but because of the presence of the dominant allelomorph of the hereditary gene for hemophilia, which is also present in non-hemophilic males. There is thus no basis for Birch's assumption that women who transmit the disease must potentially have the disease. The suggestion made at the beginning of this paper is therefore offered again, that the results achieved by Birch are manifestations of the broader phenomenon that injection of a foreign protein is efficacious as a control for hemophilia. Experiments are now in progress in our laboratory in connection with the University Hospital, to test the value of this suggestion. This paper is merely to call attention to the genetic aspects of the problem.

BIBLIOGRAPHY.

Birch, C. L. 1931. Sci. 74: 16.
Bulloch, W., and Fildes, F. 1911. Treasury of Human Inheritance, Parts V and VI, London, Dulan & Co.
Davenport, C. B. 1930. Genetics 15: 401.
Klug, W. J. 1926. Deutsche Zeitschr. f. Chir. 199: 145.
Madlener, M. 1928. Arch. Rass. u. Gesellsch. Biol. 20: 390.
Minot, G. R. and **Buckman, T. E.** 1927. "Hemophilia," in Cecil, "Textbook of Medicine," p. 961, Phila., W. B. Saunders Co.
Morawitz, P. and **Lossen, J.** 1908. Deutsche Arch. f. klin. Med. 94: 110. (Pedigree 389 in Bulloch and Fildes.)
Stahel, H. 1880. Inaug. Diss., Zurich. (Pedigree 407 in Bulloch and Fildes.)
Warde, M. 1923. Brit. Med. J., 1923: 599.

ADDITIONS TO THE CATALOG OF OHIO VASCULAR PLANTS FOR 1931.*

JOHN H. SCHAFFNER,
Ohio State University.

As has been the case for a number of years past, a considerable number of new records have again been added to the Ohio state plant list. Some of these species are very conspicuous plants and it is surprising that no botanist has reported their presence in the state before. Mr. Floyd Bartley and Mr. Leslie L. Pontius deserve special credit for a number of these interesting discoveries, some of which advance the geographic boundaries of several species several hundred miles beyond their supposed limits. Since a new State Catalog is being published, the present list will be the final additions to the old 1914 Catalog of Ohio Vascular Plants. The new catalog will bring our knowledge of distribution up to date and make further study of our flora much more convenient than it has been in recent years.

25a. *Asplenium cryptolepis ohionis* Fern. Mineral Springs region, Adams Co. Margaret A. McCloud.

40. *Dennstaedtia punctilobula* (Mx.) Moore. Boulder-fern. "Red Hills," near Central College, Franklin Co. F. B. Chapman.

63. *Lycopodium complanatum* L. Trailing Club-moss. Corning, Perry Co. Rodney D. Book.

69. *Pinus rigida* Mill. Pitch Pine. Linton Twp., Coshocton Co. L. A. Robertson.

70. *Pinus virginiana* Mill. Scrub Pine. Byesville, Guernsey Co. L. A. Robertson.

75.1. *Juniperus horizontalis* Moench. Shrubby Juniper. Along a fence, apparently escaped from cultivation. Cooney, Williams Co. John H. Schaffner.

135. *Cyperus schweinitzii* Torr. Schweinitz's Cyperus. Beach at Ashtabula, Ashtabula Co. L. E. Hicks.

172.1. *Eriophorum gracile* Koch. Slender Cotton-sedge. In bog at Baumgardner's Pond., Jackson Twp., Franklin Co. R. B. Gordon and E. S Thomas.

226. *Carex varia* Muhl. Emmon's Sedge. Elyria, Lorain Co. (E. S. Steele). Received from F. O. Grover.

295.1. *Arundinaria tecta* (Walt.) Muhl. Cane. Mineral Springs region, Adams Co. "Escaped from cultivation." E. Lucy Braun and R. B. Gordon.

340. *Sphenophyllus capillaris* (L.) Britt. Hair-like Sphenophyllus. Kettle Hill, south of Lancaster, Fairfield Co. R. B. Gordon, Bruce Hill, and Wm. Ireland.

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*Papers from the Department of Botany, The Ohio State University, No. 297.

348. *Cynosurus cristatus* L. Dogtail-grass. Oberlin, Lorain Co. F. O. Grover.
368. *Elymus hirsutiglumis* Scribn. & Sm. Strict Wild-rye. Elyria. Lorain Co. (W. M. Dick). Received from F. O. Grover.
378. *Capriola dactylon* (L.) Ktz. Bermuda-grass. Cheshire, Gallia Co. Geo. W. McAllister. Hamilton, Butler Co. J. W. Timberman.
380. *Atheropogon curtipendulus* (Mx.) Fourn. Tall Gramma-grass. Clifton Gorge, Clark Co. Floyd Bartley and Leslie L. Pontius.
383. *Sporobolus asper* (Mx.) Kunth. Longleaf Rush-grass. Union Twp., Logan Co. E. N. Transeau.
389. *Calamagrostis cinnoides* (Muhl.) Scribn. Nuttall's Reed-grass. Granville, Licking Co. (H. L. Jones). Received from F. O. Grover.
416. *Phalaris canariensis* L. Canary-grass. Twinsburg, Summit Co. E. M. Herrick.
423. *Panicum miliaceum* L. Millet Panic-grass. New Vienna, Clinton Co. Katie M. Roads.
450. *Leptoloma cognatum* (Schultes) Chase. Fall Witch-grass. Kettle Hill, south of Lancaster, Fairfield Co. R. B. Gordon.
469.1. *Andropogon elliottii* Chapm. Elliott's Beard-grass. McArthur, Vinton Co. Floyd Bartley and Leslie L. Pontius. Nile Twp., Scioto Co. Conrad Roth.
470. *Andropogon virginicus* L. Virginia Beard-grass. Beach City, Sugar Creek Twp., Stark Co. W. H. Camp.
484.1. *Allium sibiricum* L. Chives. Hartsgrove, Ashtabula Co. L. E. Hicks.
547. *Juncus brachycephalus* (Engelm.) Buch. Small-headed Rush. Conneaut, Ashtabula Co. L. E. Hicks.
559. *Gemmingia chinensis* (L.) Ktz. Blackberry-lily. Wapakoneta, Auglaize Co. Wm. Kayser.
589. *Ibidium ovale* (Lindl.) House. Small-flowered Lady's-tresses. Lynx, Adams Co. Reeve Bailey and C. F. Walker.
591. *Ibidium beckii* (Lindl.) House. Little Lady's-tresses. Nile Twp., Scioto Co. Conrad Roth, C. F. Walker. Washington Twp., Jackson Co. C. F. Walker and E. S. Thomas. Colerain Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.
595. *Liparis liliifolia* (L.) Rich. Large Twayblade. Red Hills near Central College, Franklin Co. F. B. Chapman and Wm. Ireland, Jr.
599. *Corallorrhiza corallorrhiza* (L.) Karst. Early Coral-root. Sugar Grove, Fairfield Co. Glenn W. Blaydes.
603.1. *Magnolia macrophylla* Mx. Large-leaf Magnolia. At Rock Branch and Barleytown, Jackson Co. Leslie L. Pontius and Floyd Bartley.
629. *Aquilegia vulgaris* L. European Columbine. "Common escape." Andover Twp., Ashtabula Co. L. E. Hicks.
682. *Berteroa incana* (L.) DC. Hoary Berteroa. Carpenter, Meigs Co. "In alfalfa field." C. J. Willard.
688. *Camelina microcarpa* Andrz. Common False-flax. Wooster, Wayne Co. L. E. Hicks.
701.1. *Lepidium perfoliatum* L. Perfoliate Peppergrass. Bellefontaine, Logan Co. O. D. Diller. New Bremen, Auglaize Co. G. W. Owen. Barnesville, Belmont Co. Emma E. Laughlin.
740. *Dentaria maxima* Nutt. Large Toothwort. Conneaut, Ashtabula Co. L. E. Hicks.
742.1. *Dentaria multifida* Muhl. Multifid Toothwort. Delaware, Delaware Co. C. E. O'Neal.
747.1. *Brassica napo-brassica* Mill. Rutabaga. From Europe. Persistent after cultivation. New Lyme, Ashtabula Co. L. E. Hicks.
751. *Raphanus raphanistrum* L. Wild Radish. Hillsboro, Highland Co. Katie M. Roads.
809. *Chamaesyce rafinesqui* (Greene) Small. Hairy Spurge. Barnesville, Belmont Co. Emma E. Laughlin.
812. *Chamaesyce polygonifolia* (L.) Small. Knotweed Spurge. Beach at Ashtabula, Ashtabula Co. L. E. Hicks.
820. *Malva alcea* L. European Mallow. "Roadside." Brownhelm, Lorain Co. (A. A. Wright). Received from F. O. Grover.

829.1. *Hibiscus oculiroseus* Britt. Crimson-eye Rose-mallow. Stage's Pond, three miles south of Ashville, Pickaway Co. C. F. Walker, L. M. Shupe.

875. *Viola affinis* Le C. Thinleaf Blue Violet. Red Hills east of Big Walnut Creek, Central College, Franklin Co. R. B. Gordon and F. B. Chapman.

898. *Alsine graminea* (L.) Britt. Lesser Stitchwort. Beach at Ashtabula, Ashtabula Co. L. E. Hicks.

920. *Silene caroliniana* Walt. Carolina Catchfly. East Liberty, Summit Co. L. E. Hicks.

925. *Silene armeria* L. Sweet William Catchfly. Conneaut River, Ashtabula Co. L. E. Hicks.

998. *Polygonum tenue* Mx. Slender Knotweed. Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius. Kettle Hill, south of Lancaster, Fairfield Co. R. B. Gordon.

1000. *Geum rivale* L. Purple Avens. Andover Twp., Ashtabula Co. L. E. Hicks.

1002. *Geum flavum* (Port.) Bickn. Cream-colored Avens. Windsor Mills, Ashtabula Co. L. E. Hicks.

1069. *Crataegus brainerdi* Sarg. Brainerd's Hawthorn. Wapakoneta, Auglaize Co. Wm. Kayser.

1070. *Crataegus chrysocarpa* Ashe. Roundleaf Hawthorn. Wapakoneta, Auglaize Co. Wm. Kayser.

1167. *Vicia angustifolia* L. Narrow-leaf Vetch. Wapakoneta, Auglaize Co. Wm. Kayser.

1189. *Sullivantia sullivantii* (T. & G.) Britt. Sullivantia. West of Portsmouth, Scioto Co. Glenn W. Blaydes.

1248.1. *Celtis pumila* (Muhl.) Pursh. Dwarf Hackberry. Lynx, Adams Co. Conrad Roth. "Limestone cliff." Brush Creek Twp., Highland Co. Floyd Bartley and Leslie L. Pontius.

1219.1. *Pachystima canbyi* Gr. Mountain-lover. Brush Creek Twp., Highland Co. Floyd Bartley and Leslie L. Pontius.

1400.1. *Xolisma ligustrina* (L.) Britt. Xolisma. "Growing in a swamp." Liberty Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

1404. *Uva-ursi uva-ursi* (L.) Britt. Bearberry. Beach at Ashtabula, Ashtabula Co. L. E. Hicks.

1424. *Gilia rubra* (L.) Heller. Standing-cypress. Woodville, Sandusky Co. E. L. Moseley.

1464. *Gentiana quinquefolia* L. Stiff Gentian. Banks of Deer Creek, Williamsport, Pickaway Co. L. M. Shupe. South Branch of Captina Creek, Somerton, Belmont Co. Emma E. Laughlin.

1465. *Gentiana crinita* Froel. Fringed Gentian. Hocking Twp., Fairfield Co. and Williamsport, Pickaway Co. L. M. Shupe. Union Twp., Logan Co. E. N. Transeau.

1490. *Asclepias variegata* L. White Milkweed. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

1494. *Gonolobus laevis* Mx. Sandvine. Pickerington, Fairfield Co. DeWitt C. Miller.

1573. *Orobanche ludoviciana* Nutt. Louisiana Broom-rape. On *Ambrosia trifida*, banks of Ohio River, Neville, Clermont Co. John H. Schaffner. On cultivated tobacco, same locality. H. M. Taylor and A. L. Pierstorff.

1580. *Martynia louisiana* Mill. Unicorn-plant. "A common weed in a large cucumber patch." Hillsboro, Highland Co. Katie M. Roads.

1732. *Conium maculatum* L. Poison-hemlock. Condit, Delaware Co. L. E. Hicks.

1747. *Cornus rugosa* Lam. Roundleaf Dogwood. Conneaut River, Ashtabula Co. L. E. Hicks.

1778.1. *Viburnum venosum* Britt. Veiny Arrow-wood. Coal Twp., Jackson Co. Leslie L. Pontius and Floyd Bartley.

1793. *Lonicera xylosteum* L. European Fly Honeysuckle. Kingsville, Ashtabula Co. L. E. Hicks.

1817. *Lobelia puberula* Mx. Downy Lobelia. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

1834.1. *Rudbeckia umbrosa* Boynt. & Bead. Woodland Cone-flower. "In damp woods." Brush Creek Twp., Highland Co. Leslie L. Pontius and Floyd Bartley.

1850. *Helianthus tracheliifolius* Mill Throatwort Sunflower. Conneaut, Ashtabula Co. L. E. Hicks.

1883. *Parthenium hysterophorus* L. Parthenium. Hamilton, Butler Co. D. T. Herrman.

1903. *Chrysopsis mariana* (L.) Ell. Maryland Golden-aster. McArthur, Vinton Co. Leslie L. Pontius and Floyd Bartley.

1904. *Solidago squarrosa* Muhl. Stout Goldenrod. Washington Twp., Scioto Co. Conrad Roth.

1927. *Bellis perennis* L. European Daisy. "In lawn." Columbus, Franklin Co. E. S. Thomas.

1931.1. *Aster schreberi* Nees. Schreber's Aster. Conneaut, Ashtabula Co. L. E. Hicks. Brush Creek Twp., Highland Co. Floyd Bartley and Leslie L. Pontius. Oberlin, Lorain Co. F. O. Grover.

1941. *Aster patens* Ait. Late Purple Aster. Liberty Twp., Jackson Co. Floyd Bartley and Leslie L. Pontius.

1947.1. *Aster concinnus* Willd. Narrowleaf Smooth Aster. Brush Creek Twp., Highland Co. "Limestone cliff." Floyd Bartley and Leslie L. Pontius.

1953. *Aster dumosus* L. Bushy Aster. Catawba Island, Ottawa Co. R. B. Gordon.

1967. *Ionactis linariifolius* (L.) Greene. Stiffleaf Aster. Liberty Twp., Jackson Co. Also in Coal Twp. Floyd Bartley and Leslie L. Pontius.

1983. *Lacinaria spicata* (L.) Ktz. Dense Blazing-star. Hocking Twp., Fairfield Co. L. M. Shupe.

1991. *Anthemis arvensis* L. Field Dog-fennel. Hillsboro, Highland Co. Katie M. Roads.

2004. *Artemisia vulgaris* L. Common Mugwort. Buchtel, Athens Co. Len. Stephenson.

2005. *Artemisia pontica* L. Roman Wormwood. Rock Creek, Ashtabula Co. L. E. Hicks.

2019.2. *Carduus crispus* L. Curled Plumeless Thistle. "Growing in pasture field." Pickaway Twp., Pickaway Co. Floyd Bartley and Leslie L. Pontius.

2028.1. *Centauria maculosa* Lam. Spotted Star-thistle. Rock Mill, Fayette Co. "Abundant in a pasture field." Floyd Bartley and Leslie L Pontius.

2035.3. *Apargia autumnale* (L.) Hoffm. Fall Hawkbit. Trumbull, Ashtabula Co. L. E. Hicks.

2039. *Sonchus arvensis* L. Field Sow-thistle. Beach at Ashtabula, Ashtabula Co. L. E. Hicks.

2051.1. *Nabalus trifoliolatus* Cass. Tall Rattlesnake-root. Conneaut Harbor, Ashtabula Co. L. E. Hicks.

2061.1. *Hieracium florentinum* All. King-devil. Conneaut, Ashtabula Co. From Europe. L. E. Hicks.

2062.1. *Hieracium pratense* Tausch. Field Hawkweed. Williamsfield Twp., Ashtabula Co. L. E. Hicks.

The Queen of the Sciences.

A group of publishers, headed by the Williams and Wilkins Co., have undertaken the publication of a series of volumes presenting the essential features of those fundamental sciences which are the foundation stones of modern industry. The first volume of this "Century of Progress" series is at hand, a delightful excursion into the field of mathematics. Starting with a chapter on points of view, the author progressively analyzes mathematical truth, algebra, geometry, arithmetic, and the concept of the infinite. It is all done in a whimsical yet strictly scientific vein, and will give several hours of extremely pleasurable and profitable reading. May the volumes to follow live up to the standard set by the first one to appear.

The Queen of the Sciences, by E. T. Bell, Ph. D., 138 pp. Baltimore, the Williams and Wilkins Co., 1931. $1.00.

CORRECTION.

In the paper by Robert M. Geist, entitled "Additional Mallophaga from Ohio Birds," appearing in the OHIO JOURNAL OF SCIENCE for November, 1931, the following correction should be noted:

In the first sentence of the second paragraph of the article, the sentence, "The following list includes 45 additional species . . . ." should read, "The following list includes 21 additional species . . . ."

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THE CEPHALOPOD GENERA CYRTENDOCERAS AND OELANDOCERAS.

AUG. F. FOERSTE,
Dayton, Ohio.

The generic term *Cyrtendoceras* was proposed by Adolf Remele in 1886 for a fragment of a cephalopod for which however he never supplied a specific name. Several years ago the Remele collection came into the possession of the Museum of Natural History at Berlin, and the specimen upon which Remele founded his genus *Cyrtendoceras* was loaned to the writer for study. It is described here under the name *Cyrtendoceras remelei.* This specimen is by no means the best, among those known at present, to serve as a genotype, but it is at least adequate, and therefore is here accepted.

In 1892, Gerhard Holm described two species under the names *Endoceras* (*Cyrtocerina*) *hircus* and *Endoceras* (*Cyrtocerina*) *schmidti*, which evidently are congeneric with Remele's type of *Cyrtendoceras*. These also were borrowed for study.

In the U. S. National Museum there is a fourth species of this genus, here described under the name *Cyrtendoceras estoniense.*

In addition, Dr. Gustaf Troedsson called to my attention the presence of certain cephalopods in the collections of the Royal Museum of Natural History and of the Geological Survey of Sweden, both at Stockholm, which agree with *Cyrtendoceras* in the location of the siphuncle on the concave side of the curved conch, but differ in the relatively much smaller size of these siphuncles. These specimens are described here under the names *Oelandoceras haelluddenense*, *Oelandoceras byrumense*, and *Oelandoceras kristdalaense*.

In 1906 Dr. Rudolf Ruedemann described a species under the name *Cyrtendoceras* (?) *priscum*, but the reference of this species to the genus *Cyrtendoceras* is indicated in the original

description as doubtful, and on that account the latter can scarcely be cited as the first named species *definitely* referred to *Cyrtendoceras*. It is a much smaller form, strongly coiled, and, in the opinion of the present writer, is generically distinct.

For the loan of the various specimens here cited, the writer is indebted to Dr. W. O. Dietrich, Dr. Gustaf Troedsson, Dr. R. S. Bassler, and Dr. Rudolf Ruedemann. Their kindness is greatly appreciated.

All of the species here described came from the Orthoceras limestone of the Baltic areas of Europe. In American terminology their horizon is approximately Chazyan, but no more definite correlation is possible since no trace of the fauna of the Orthoceras limestone has been discovered so far anywhere in American areas.

Both *Cyrtendoceras* and *Oelandoceras* have their siphuncles located on the concave side of the conch, and therefore are endogastric. In *Cyrtendoceras* the septal necks extend backward for a length of one camera and then invaginate into the tops of the necks immediately beneath. Within the camerae they present concave vertical outlines. Their structure, therefore, is holochoanoidal and their relationship is with the Endoceratida.

In *Oelandoceras*, on the contrary, the septal necks appear to be short, and to terminate within the upper part of the camerae. The gap between the successive septal necks is occupied by thin connecting rings which extend downward from the lower margin of one septal neck and invaginate at the base into the neck immediately beneath. These connecting rings do not present concave vertical outlines. If this interpretation of their structure is correct, *Oelandoceras* presents an ellipochoanoidal structure, similar to that of the Orthochoanites of Hyatt.

There is a possibility that the ellipochoanoidal structure of *Oelandoceras* developed from the holochoanoidal structure of forms similar to *Cyrtendoceras*. In holochoanoidal forms the septa appear to grow backward from the septa from which they orignate. In *Oelanderocas* the upper part of the septal neck, which develops first, is thicker than the lower part, which develops later. The thinner part apparently corresponds to the connecting ring of ellipochoanoidal conchs. It is not always possible to determine definitely whether a certain conch presents holochoanoidal or ellipochoanoidal structure, and the subject merits further study.

The original description of *Cyrtendoceras*, as presented by Remele, is here republished, in free translation.

Cyrtendoceras (Remele) Foerste.

Tageblatt der 59. Versammlung Deutscher Naturforscher und Aertzte zu Berlin vom 18.–24. September, 1886, p. 338 (1886).

Mr. Remele exhibits a peculiar curved cephalopod from Ordovician drift in the vicinity of Wriezen (in the Province of Brandenburg). This fossil, which is of fair size, represents a new generic type, called *Cyrtendoceras* by the speaker. In addition to a strong sickle-like curvature, exactly as in *Cyrtoceras*, the conch exhibits a very gradual increase in size, as well as very numerous camerae. Most remarkable of all, however, is the location of the siphuncle in the immediate vicinity of the concavely curved side of the conch. This siphuncle agrees with that of the vaginate orthoceroids (*Endoceras* Hall) not only in its marginal location, but also in its structure, since it is girdled by oblique transverse annulations which indicate the lower ends of the backward directed septal funnels, and which occur at intervals equal to those between the septa.

The drift material enclosing this conch is a limestone, chiefly of a light greenish-gray color, but locally with light brownish-gray parts, and with isolated yellowish plates of calcite. Among other fossils it contains, as more noteworthy, also *Echinosphaerites aurantium* Gyllenhal sp., *Illaenus centaurus* Angelin, and *Orthoceras barrandei* Dewitz. The two fossils named last indicate that this rock belongs to the Swedish Upper Gray *Orthoceras* limestone, although it differs in appearance from that usually presented by the rock of this horizon.

This specimen on which Remele founded his genus *Cyrtendoceras* is described in the following lines under the name *Cyrtendoceras remelei*.

The *Illaenus centaurus* Angelin is not identical with that of Dalman, and its name was changed by Gerhard Holm to *Illaenus chiron*.

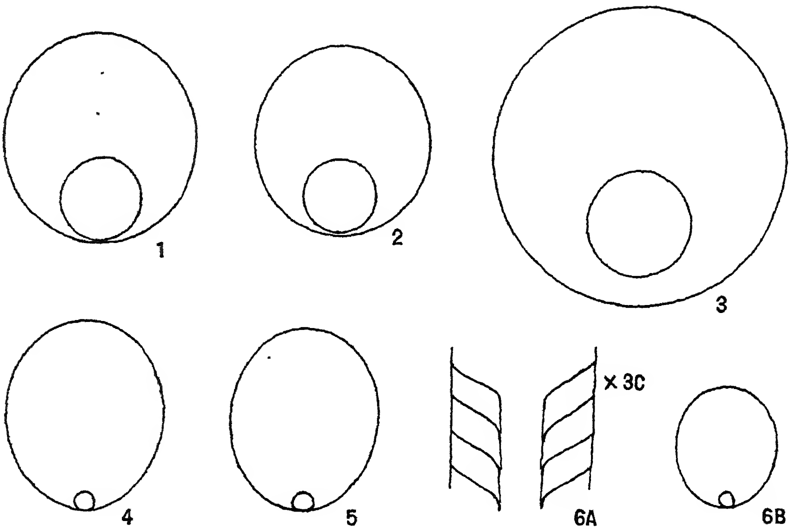
Cyrtendoceras remelei sp. nov.

(Plate II, Figures 2 A, B, C.)

Specimen approximately 45 mm. long when measured along its convex outline. Curved lengthwise, its radius of curvature along its convex outline being 40 mm. Its dorsoventral outline enlarges from 18 mm. at its base to 21 mm. at a point 37 mm. farther up. Its lateral diameter appears to be only from 1.5 to 2 mm. less than its dorsoventral one. The cross-section is more narrowly rounded along the convex side of the conch than along its concave side. There are 6 camerae in a length equal to the dorsoventral diameter of the conch. The sutures of the septa curve faintly downward laterally. The concavity of the upper septa equals almost 5 mm. Where the dorsoventral diameter of the conch is 21 mm., that of the siphuncle is 9 mm. The

latter is circular in cross-section, and its distance from the adjacent wall of the conch is at least 0.5 mm. The shell is thin and its surface appears to have been weakly annulated, though the evidence for this is not clear.

Occurrence.—Found in a loose boulder at Eberswalde, Germany; evidently from some locality in the Ordovician in the Baltic area. Label dated May 23, 1884. In the light gray Orthoceras limestone, the horizon with typical Lituitidae.



SECTIONS SHOWING LOCATION AND RELATIVE SIZE OF SIPHUNCLES.

1. *Cyrtendoceras hircus*, section 50 mm. above base. (Plate I, Figs. 1 A, B.)
2. *Cyrtendoceras estoniense*, section at top of type. (Plate II, Figs. 3 A, B.)
3. *Cyrtendoceras schmidti*, section 30 mm. above base. (Plate I, Figs. 2 A, B.)
4. *Oelandoceras byrumense*, section 32 mm. above base. (Plate II, Figs. 1 A, B.)
5. *Oelandoceras kristdalense*, section at base. (Plate II, Figs. 4 A, B, C.)
6. *Oelandoceras haelluddenense:* A, transverse vertical section, magnified 3 diameters, but not including entire width of conch; B, section 38 mm. above base. (Plate I, Figs. 3 A, B.)

The rock fragment containing the *Cyrtendoceras remelei* contains also a straight conch which may be the straightened part of a *Lituites lituus;* also a conch with a coiled portion 30 mm. in diameter from which the living chamber continues tangentially for a length of 20 mm., the surface striae being directly transverse, identified as *Lituites procerus* Remele (Text figure 7) on the label; and, finally, a small orthoceroid with central siphuncle, which may be a fragment of *Orthoceras barrandei* Dewitz, as identified by Remele. (Plate II, figure 5.)

Remarks.—The siphuncle of this species differs from that of *Cyrtendoceras hircus* and *Cyrtendoceras estoniense* in not being in actual contact with the concave side of the conch, though only slightly removed from the latter. On the contrary, it differs from that of *Cyrtendoceras schmidti* in being much closer to this side, the interval in the latter species being about 3 or 4 mm. From the latter species, *Cyrtendoceras remelei* differs by traces of weak annulation, both on the surface of the shell and also on the cast of its interior; and the number of camerae within a length equal to the dorsoventral diameter is relatively greater at an earlier stage of growth.

This specimen is selected here as the genotype, thus conforming, as far as possible, with the intentions of Remele.

7. *Lituites procerus* Remele; lateral view.

Cyrtendoceras hircus (Holm).

(Plate I, Figures 1 A, B; Text Figure 1.)

Endoceras (*Cyrtocerina*) *hircus* Holm. Geol. Foren. i Stockholm Forhandl., vol. 14, p. 127, pl. 4, figs. 1–3; pl. 5, figs. 1–5 (1892).

Holotype 115 mm. long when measured along its convex outline. Curved lengthwise, the lower half of its convex outline having a radius of 40 mm., changing to 52 mm. along its upper half. Only the basal part of the living chamber, for a length of 6 mm., is preserved. The dorsoventral diameter enlarges from 18.5 mm. at the base of the specimen to 36 mm. at the base of the living chamber, the corresponding lateral diameters being estimated at 17 mm. and 30 mm. The number of camerae in a length equal to the dorsoventral diameter of the conch varies from 5 at the lower end of the specimen to 7.3 at its top. The siphuncle is large, compared with the dorsoventral diameter of the conch, its dorsoventral diameter increasing from 8 mm. at its lower

end to 13 mm. at its top. The cross-section of the siphuncle is assumed to have been circular. The concavity of the septa varies from 4.5 mm. at the lower end of the specimen to 9 mm. at its top. The septal necks curve convexly inward for the greater part of their vertical outlines, changing to convexly outward a short distance before invaginating into the top of the neck directly beneath. In consequence, the segments of the siphuncle within the camerae present concave vertical outlines. The thickness of the shell varies from 0.2 mm. along its convex outline to 0.5 mm. along its concave one. Its surface is transverse striated and weakly ribbed or annulated. Their course is almost directly transverse, the downward curvature along the convex side of the conch being slight. The striae are relatively low and broad, and number 9 or 10 in a length of 10 mm. The annulations are only weakly defined, and vary from 4 in a length of 10 mm. at 50 mm. above the base of the specimen to about 2 in 10 mm. farther up, their distances apart being somewhat irregular.

Occurrence.—Vedby, in Oeland, Sweden; in the gray Lituites limestone member of the Orthoceras limestone. No. *Mo. 4493,* Riksmuseum, Stockholm, Sweden.

Remarks.—At the base of the holotype the upper part of an endocone apparently is preserved for a length of at least 2 camerae. Where the dorsoventral diameter of the siphuncle is 8 mm., that of the endocone is scarcely 6 mm. In figure 5 on Plate V of the publication by Holm, cited above, there is an endocone figured for a length of 25 mm., its lower end probably having been at least 5 mm. longer.

Cyrtendoceras estoniense sp. nov.

(Plate II, Figures 3 A, B; Text Figure 2.)

Holotype 93 mm. long when measured along its convex outline. Curved lengthwise, with a radius of 60 mm. along the lower part of its convex outline, changing to 120 mm. toward its top. The dorsoventral diameter enlarges from 10 mm. at its base to 24.5 mm. at a point 90 mm. farther up. The corresponding lateral diameters are estimated as being about the same, the cross-section being either circular or nearly so. At the base of the specimen is a single camera 2 mm. long, indicating 5 camerae in a length equal to the dorsoventral diameter of the conch. At its top the septal necks indicate the presence of 5 camerae in a length of 26 mm. At the base of the specimen the diameter of the siphuncle is 3.5 mm., while at the top it varies between 8 and 9 mm., being widest at the septa. At the lower end of the specimen this siphuncle is in contact with the concave side of the conch, while at its top it is 1 mm. distant. The septal necks present concave vertical outlines within each of the camerae. Along midlength a long endocone, or rather the solidified matrix or spiculum filling its interior, is exposed. Apparently this spiculum is 32 mm. long, but its surface continues to show faint annulations for some distance below the point at which it becomes free

from the inner walls of the siphuncle. The surface of the shell is distinctly but not strongly annulated, the annulations being directly transverse. At its lower end there are slightly over 5 annulations in a length equal to the dorsoventral diameter of the conch, this number being exactly 5 at its top. In addition, the surface of the shell is transversely striated, 9 striae occupying a length of 2 mm. at the base of the specimen, but 12.5 mm. at its top. At its base they are closely crowded; at its top they are widely separated, the intervals between the striae being much greater than the width of the latter.

Occurrence.—From some unknown locality in Estonia. Labelled as coming from the Vaginatenkalk of Schmidt, the horizon B 3, to which the name Kunda formation is applied by Raymond. No. 84762, U. S. National Museum.

Cyrtendoceras schmidti (Holm).

(Plate I, Figures 2 A, B; Text Figure 3.)

Endoceras (*Cyrtocerina*) *schmidti* Holm. Geol. Foren. i Stockholm Forhandl., vol. 14, p. 129, pl. 6, figs. 1, 2 (1892).

Holotype 120 mm. long when measured along its convex outline. Curved lengthwise, the lower half of its convex outline having a radius of 70 mm., changing to 80 mm. along its upper part. Only a part of the phragmacone is at hand, and there is no distinct shortening of its upper camerae to indicate that the conch had reached its gerontic stage. The specimen is broken in such a way that the concave outline of the conch is not preserved; however, its dorsoventral diameter is estimated to have increased from 34 mm. at its base to 44 mm. at its top. The corresponding lateral diameters are estimated at 30 mm. and 40 mm. The number of camerae in a length equal to the dorsoventral diameter of the conch is about 4.5 along the entire specimen. The sutures of the septa curve slightly downward laterally. The concavity of the upper septa equals about 13 mm. The diameter of the siphuncle can be estimated only at mid-length of the specimen, this diameter being approximately 14 mm. where that of the conch is about 39 mm. As far as can be determined from the holotype, the siphuncle was not in contact with the concave side of the conch, but was between 3 and 4 mm. distant from the latter. The surface of the shell, as far as preserved, appears to be smooth.

Occurrence.—Kandel, in Estonia; in the Echinosphaerites limestone, at the horizon C 1a. No. *Mo. 4492*, Riksmuseum, Stockholm, Sweden.

Remarks.—The structure of the siphuncle appears to be similar to that of *Cyrtendoceras hircus*. The septal necks curve inward for the greater part of the length of a camera, and then curve convexly outward just before invaginating into the top of the neck beneath. However, in *Cyrtendoceras hircus* the siphuncle is in contact with the concave wall of

conch, while in *Cyrtendoceras schmidti* it appears to have been free by an interval of several millimeters. Both conchs evidently completed more than one volution (possibly one and a half), but the apical end did not come in contact with the nearest part of the following volution.

Oelandoceras gen. nov.

Genotype: *Oelandoceras haelluddenense* Foerste.

Conch curved lengthwise, moderately compressed laterally. Camerae short, with the sutures of the septa rising toward the convex outline of the conch. Siphuncle relatively small, in contact with the concave side of the conch, its location being endogastric. The vertical outlines of the segments of the siphuncle are straight or only slightly concave, their lower margins invaginating into the top of the septal necks immediately beneath. The septal necks are short and appear to be slightly thicker than the connecting rings, the latter forming the greater part of the length of the segments of the siphuncle. This structure is most distinct in the genotype, the other two species, here referred to the same genus, not exhibiting the structure of the siphuncle equally well.

Oelandoceras haelluddenense sp. nov.

(Plate I, Figures 3 A, B; Text Figures 6 A, B.)

Holotype about 52 mm. long when measured along its convex outline, all of this length belonging to the phragmacone. Curved lengthwise, its radius of convex curvature varying from 20 mm. at the lower end of the specimen to 39 mm. at its top. Its dorsoventral diameter enlarges from 8.7 mm. near its base to 18 mm. at a point 50 mm. farther up. The corresponding lateral diameters are 7.1 mm. and 16 mm. Along the upper part of the specimen 8 camerae occur in a length equal to the dorsoventral diameter. The sutures of the septa curve slightly downward laterally, but rise higher toward the convex outline of the conch than toward the concave outline. In consequence, the sutures of the saddles on this convex side tend to be slightly angulate along their median line. The concavity of the septa is 3 mm. where the dorsoventral diameter of the conch is 16 mm. Here the diameter of the siphuncle is 2 mm. The septal necks are about two-fifths of the length of the camerae, and the connecting rings are thinner, lighter colored, and apparently cylindrical in form. The siphuncle apparently is in contact with the concave wall of the conch. The surface of the shell is striated transversely, the striae curving increasingly downward in a direction toward the convex outline of the conch, forming a broad, shallow sinus on that side, but where crossing the siphuncular side of the conch they curve downward more narrowly, forming a shallow sinus 6 or 7 mm. wide at the top of the specimen.

Occurrence.—On Oeland, at Haelludden, near Torp, in the glauconite member of the gray Vaginitenkalk. Collected by Gerhard Holm in 1893. In the paleontological collection of the Geological Survey of Sweden.

Oelandoceras byrumense sp. nov.

(Plate II, Figures 1 A, B; Text Figure 4.)

Holotype 75 mm. long when measured along its convex outline. Curved lengthwise, its radius of curvature being 60 mm. along the lower half of its convex outline, changing to 100 mm. toward its top. Its dorsoventral diameter enlarges from 22 mm. at a point 10 mm. above its base to 29.5 mm. at the bottom of the living chamber, which is 52 mm. farther up. Where the dorsoventral diameter of the conch is 28.5 mm. its lateral one is 24 mm. Here about 10 camerae occur in a length equal to the dorsoventral diameter, and the diameter of the siphuncle is slightly over 3 mm. The siphuncle is in direct contact with the concavely curved side of the conch. The sutures of the septa curve distinctly downward on approaching the siphuncle and also laterally, the saddles rising higher on the antisiphonal side of the conch than along its siphonal side. Of the living chamber a length of 16 mm. remains. The shell at this point appears to be thick and transversely striated. The structure of the siphuncle appears to be similar to that of *Oelandoceras haelluddenense*, but its details are not distinctly defined.

Occurrence.—On Oeland, at Byrum, in the glauconite bearing layer in the Vaginatenkalk. Collected by Gerhard Holm in 1891. In the paleontological collection of the Geological Survey of Sweden.

Remarks.—This species is readily distinguishable from *Oelandoceras haelluddenense* by its larger size and smaller lengthwise curvature.

Oelandoceras kristdalaense sp. nov.

(Plate II, Figures 4, A, B, C; Text Figure 5.)

Holotype 40 mm. long when measured along its convex outline. Curved lengthwise, its radius of curvature along this convex outline being about 100 mm. Its dorsoventral diameter enlarges from 25 mm. at the base of the specimen to 30 mm. at a point 18 mm. farther up. The corresponding lateral diameters are 20 mm. and 23.6 mm. Immediately below the level at which the dorsoventral diameter is 30 mm. there are about 11 camerae in a corresponding length. The sutures of the septa curve downward slightly laterally and also along the upper part of the concave side of the conch, but rise distinctly along its convex side, forming broad saddles here. The siphuncle is about 3 mm. in diameter where the dorsoventral diameter of the conch is 30 mm., and is in contact with the concave side of the conch. Its structure appears similar to that of *Oelandoceras haelluddenense* but with a more concave curvature along the upper part of the vertical outline of its segments. Its structure is not clearly defined. The surface of the shell is almost smooth, but with distant transverse lines parallel to the sutures of the septa and about equal to the latter in number; also relatively distant vertical lines; both sets of lines very faint.

Occurrence.—In Smoland, Kristadala, Humlenaes; from some unknown horizon, but assumed to belong to the glauconite bearing layer of the Vaginatenkalk, since green glauconite grains are relatively abundant in the matrix. No. *Mo. 4491*, in the Riksmuseum, Stockholm, Sweden.

Remarks.—This specimen evidently is closely related to *Oelandoceras byrumense*, and may belong to the same species, but it appears less curved lengthwise than the latter at the same diameter of the conch.

EXPLANATION OF PLATES.

Plate I.

Fig. 1. *Cyrtendoceras hircus* (Holm). A, dorsoventral section through the siphuncle; B, weathered exterior with traces of transverse markings on surface of shell. Vedby, in Oeland, Sweden; in the gray Lituites limestone member of the Orthoceras limestone. No. *Mo. 4493*, Riksmuseum, Stockholm, Sweden. (Text Figure 1.)

Fig. 2. *Cyrtendoceras schmidti* (Holm). A, exterior surface, exposing parts of the camerae; B, dorsoventral section through the siphuncle, resulting from a break; concave outline of siphuncle reached only along lower part of specimen. Kandel, Estonia; in the Echinosphaerites limestone immediately over the Orthoceras limestone, in horizon C 1 a. No. *Mo. 4492*, Riksmuseum, Stockholm, Sweden. (Text Figure 3.)

Fig. 3. *Oelandoceras haelluddenense* Foerste. A, concave ventral side of conch; B, lateral side. At Haelludden, near Torp, on Oeland, Sweden; in the glauconite member of the gray Vaginitenkalk or Orthoceras limestone. Museum of Geological Survey of Sweden. (Text Figures 6 A, B.)

Plate II.

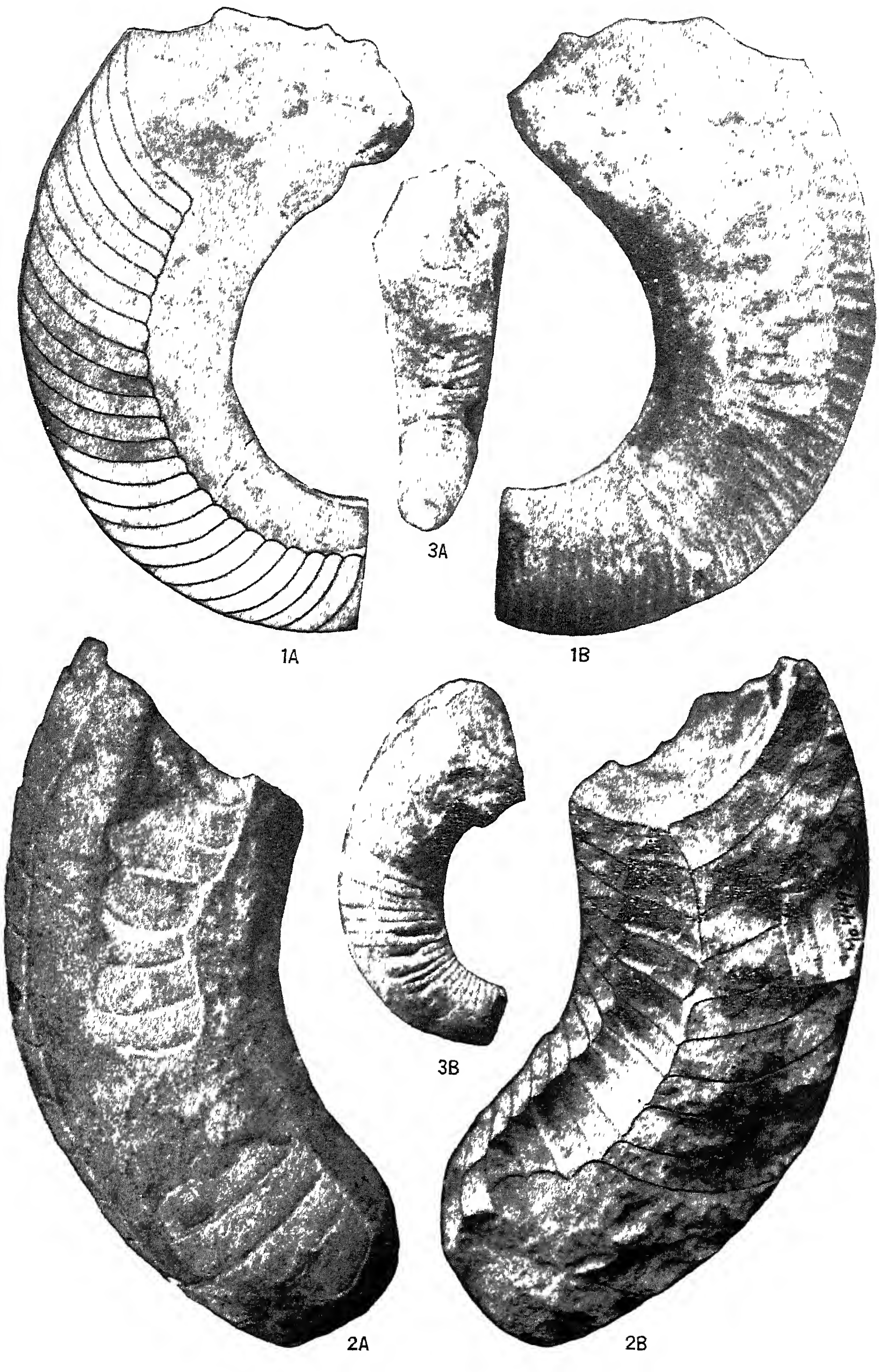
Fig. 1. *Oelandoceras byrumense* Foerste. A, convex dorsal side; B, lateral view. Byrum, on Oeland, Sweden; in the glauconite bearing member of the Vaginatenkalk. Museum of Geological Survey of Sweden. (Text Figure 4.)

Fig. 2. *Cyrtendoceras remelei* Foerste. A, lateral view; B, lower half of fragment, viewed from above, showing location of siphuncle close to concave ventral side of conch; C, cross-section, oriented as in preceding figure. In erratic boulder found at Eberswalde, northern Germany; in the upper gray member of the Orthoceras limestone. Museum of Natural History, Berlin, Germany.

Fig. 3. *Cyrtendoceras estoniense* Foerste. A, lateral view; B, dorsoventral vertical section, showing greater part of length of siphuncle, with endocone at middle, and one camera at base. From unknown locality in Estonia, labelled as from the Vaginatenkalk of Schmidt, at horizon B3. No. *84762*, U. S. National Museum. (Text Figure 2.)

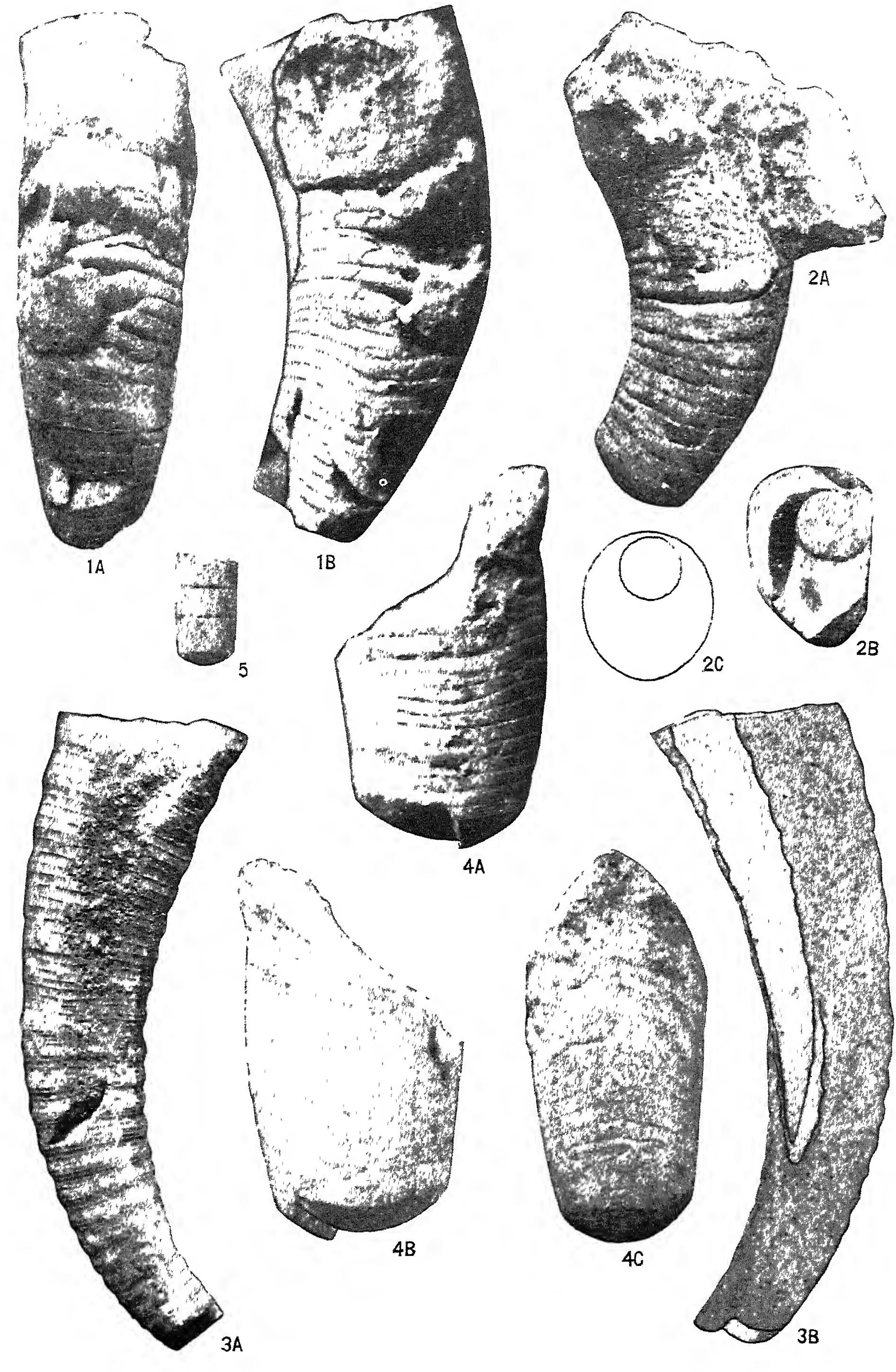
Fig. 4. *Oelandoceras kristdalaense* Foerste. A, left lateral side; B, right lateral side; C, convex dorsal side; B, C, with faint transverse and vertical surface markings. Smoland, Kristdala, Humlenaes; from glauconite bearing layer in Vaginatenkalk. No. *Mo. 4491*, Riksmuseum, Stockholm, Sweden. (Text Figure 5.)

Fig. 5. *Orthoceras (?) barrandei* Dewitz. In same rock fragment as the type of *Cyrtendoceras remeli*, and the specimen of *Lituites procerus* Remele shown in Text Figure 7.



1A 1B 3A 2A 2B 3B

PLATE II.



NELSON LEDGE STATE PARK.

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INTRODUCTION.

It occurred to the writer that more should be known by the public of the scenery of Ohio and especially of the parks of the State. Little has been done to bring to the attention of the people the natural beauty and features of scientific interest in the parks. For that reason we hope to stimulate more enthusiasm in the appreciation of the natural wonders of Ohio.

Much credit is due State Forester Edmund Secrest, and other public-spirited citizens for their tireless efforts to preserve the beauty spots and forest lands for the benefit of the public and future generations. Let us hope that the work which they began will be carried to completion in the near future.

The map (Fig. 1), accompanying this paper shows the location of the trails and places in the park. The writer wishes to acknowledge the aid received from his assistants George Crowl and George Yunck of the Geology Department of Wooster College, and Arthur Murray and Malcolm McNutt of Wooster.

HISTORICAL.

Before the coming of the white man, the region in the vicinity of Nelson Ledge was the hunting ground of the Indians. That it was a favorite haunt of the red man is indicated by the fact that many implements have been found in the locality. Cornelius Baldwin, an early settler, who owned the first farm to the south, where the ledge begins, was an ardent collector of Indian relics. Fifty years ago the Baldwin collection was presented to Hiram College where it is on display in the museum.

In 1870 Nelson Ledge experienced a gold rush. It was reported that gold had been discovered in the rock formations. But it was soon learned that the yellow crystals were not gold but iron pyrite, commonly known as "Fool's Gold."

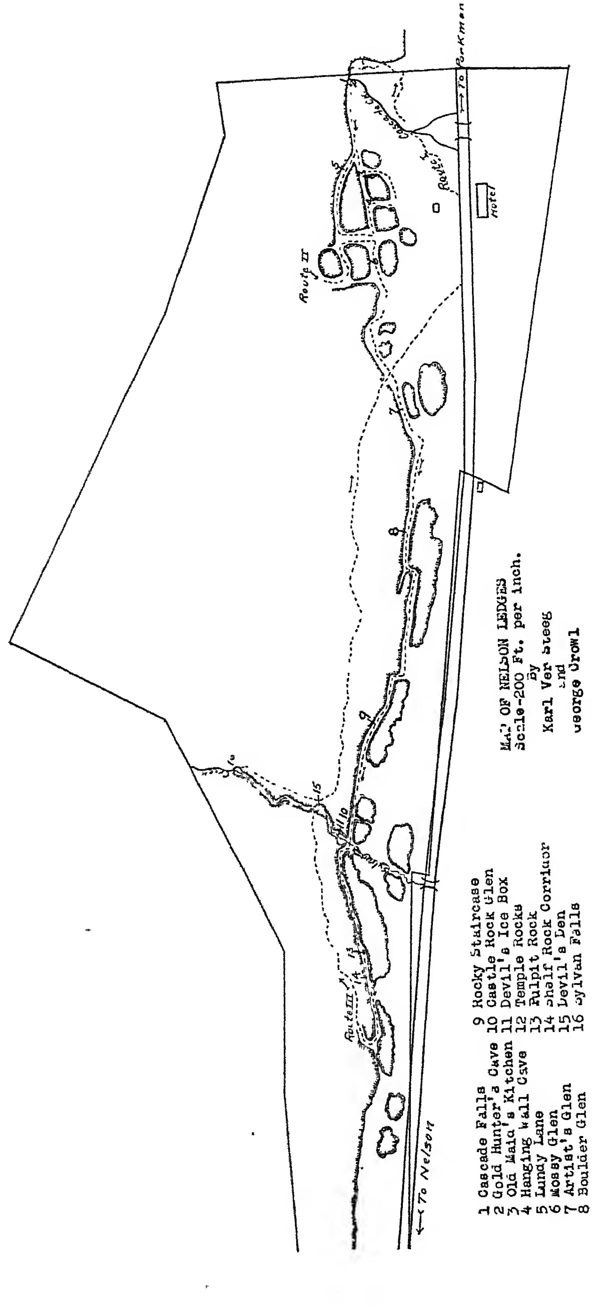


FIG. 1. Map of Nelson Ledge State Park, showing trails, locations and boundary lines.

For many years Nelson Ledge has been known as one of the natural wonders of Ohio. Constant urging by interested parties, who were anxious to preserve it in its natural state, led to its purchase in 1925 as a State park.

LOCATION, DRAINAGE AND TOPOGRAPHY.

Nelson Ledge State Park is located in the extreme northeastern township of Portage County, two and one half miles from the point where Portage, Geauga and Trumbull counties meet. It lies about five miles from Garrettsville and approximately three miles from Parkman, and can be easily reached by paved roads which lead from Cleveland, Youngstown and Akron.

In the broad valley to the east of Nelson Ledge, not far from Cascade Falls Hotel, is located the continental divide. Two streams, Cascade Creek and Sylvan Creek flow through the park; each has a beautiful cascade in its course, and arises on the upland in a glacial marsh, located about a quarter of a mile west of the Ledge. These creeks join to form a tributary that flows northward into the Grand River, which flows from Parkman through a deep, narrow gorge for a distance of about two or more miles, the waters ultimately reaching Lake Erie. To the south of the divide, a stream referred to on the map as Nelson Ditch flows south to join Tinker Creek, the waters of which ultimately flow into the Mahoning River, a tributary of the Ohio.

The State of Ohio comprises two major topographic divisions, the Erie Plain in the northwest, occupying about one-fourth of its area and the Allegheny Plateau in the east and southeast, occupying nearly all the rest of the State. Portage County lies in the northern extension of the Allegheny Plateau in Ohio. This upland is really the western continuation of the plateau, covering New York and western Pennsylvania. It has been deeply trenched by the Grand River and its tributaries on the north, and the Mahoning River on the south.

From Thompson Ledge in Thompson Township, Geauga County, the eastern outcrop of the Sharon Conglomerate, in general, follows a nearly north and south line, with indentations across Thompson, Montville, Huntsburg, Middlefield, and Parkman Townships in Geauga County and Nelson Township in Portage County, when it turns southeasterly across Windham Township. Along this north and south escarpment there are

various ledges and glens affording exposures of the Sharon Conglomerate; the best known is Nelson Ledge. Kennedy Ledge, located a mile directly east of Nelson Ledge is considered

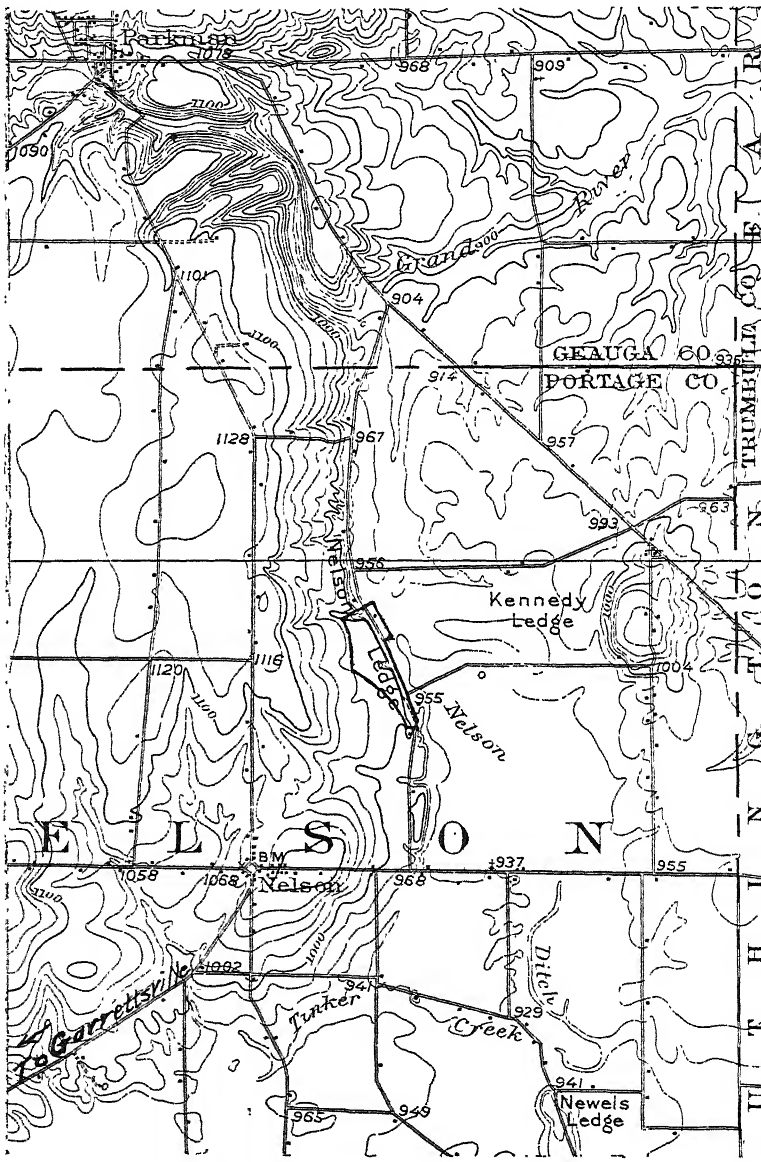


FIG. 2. Section of the Garrettsville quadrangle, showing Nelson Ledge State Park.

an outlier of the Sharon Conglomerate and stands well above the surrounding drift-covered plain.

The accompanying topographic map, a portion of the Garrettsville quadrangle, shows a broad, nearly flat plain lying between Nelson and Kennedy ledges. It is probable that in preglacial time a stream of considerable size occupied this valley. Its present floor displays the characteristic, hummocky topography of the ground moraine. To the east of the town of Nelson and in the vicinity of Nelson Ledge there are broad expanses of marsh-land. Nelson Ledge, a long erosional cliff, bounds the upland on the east and forms a nearly vertical wall for a distance of about 150 feet from the road which parallels its base. The upland to the west of the ledge has an average altitude of about 1,100 to 1,120 feet above sea level, rising to the west. The upland appears to be fairly flat, the rise to the west being gradual. The relief is characteristic of a glacial topography, rolling, with knobs, hollows, flat expanses and marshes here and there. Both Nelson and Parkman are located on the upland at an elevation of about 1,160 feet above sea level. The ascent is rather steep from the lowland to the upland, a rise from an altitude of 900+ to 1,100+ feet, a distance of 200 to 250 feet.

STRATIGRAPHY.

The indurated rocks in Ohio are all of sedimentary origin and of Paleozoic age, ranging from Middle Ordovician to Permian. They have a total thickness of 5,400 to 5,800 feet and comprise limestone, dolomite, shale, sandstone and conglomerate, with beds of rock-salt and gypsum in the middle part of the section and beds of coal and fire-clay in the upper part. The Lower Ordovician and Upper Cambrian are not exposed in the State and they rest on the pre-Cambrian complex made up of metamorphic rocks such as those which appear from beneath the Paloozoic formations in Wisconsin, Minnesota and Canada. Over-lying, and in most places concealing the hard rocks of the northern two-thirds of the State, is a blanket of glacial drift, which in places reaches a thickness of several hundred feet.

In the vicinity of Nelson Ledge the exposed rock formations are sedimentary and were laid down in the Mississippian and Pennsylvanian periods. Glacial drift covers the bed rock in most places but appears to be absent or thin at the Ledge and

on the upland immediately to the west. Well-logs indicate that the thickness of the glacial drift in the pre-glacial valley to the east of the Ledge varies from 80 to 120 feet.

The Cuyahoga formation which lies beneath the Sharon Conglomerate at Nelson Ledge belongs to the Waverly Series, a group of formations laid down during the Mississippian period. It consists mainly of shale and is commonly known as the "Cuyahoga Shale" but it contains in addition to shale a considerable amount of sandstone. The upper five or more feet of black or grey Cuyahoga shale are exposed at Nelson Ledge, in Gold Hunter's Cave, located at the foot of Cascade Falls. The Sharon Conglomerate lies unconformably above it. According to Wilber Stout, State Geologist of Ohio, this formation is correlative with the conglomerate at Sharon, Pennsylvania and with the Olean around Olean, New York. Farther south in Ohio it is prominent at Cuyahoga Falls, at the quarries near Massillon, at Glass Rock in Perry County and is at its best in eastern Pike and western Jackson counties in southern Ohio, where its thickness is from 50 to more than 200 feet. It appears to be correlative with the Mansfield of western Kentucky and southern Indiana. The Sharon Conglomerate is well displayed at Nelson Ledge, where it is massive and the pebbles numerous. Some of them are as much as 2½ inches long and 1½ inches in diameter; as large as a hen's egg. In southern Ohio the largest pebbles, occasional ones, are as large as the fist. Usually pebbles the size of a hen's egg are rather uncommon, most of the material being fairly fine. The great majority of pebbles range from one-half to three-quarters of an inch in size at Nelson Ledge. The matrix of the conglomerate is a coarse grained sandstone or grit, in which the pebbles are embedded. Where freshly broken, the sandstone is buff or red in color. The weathered surface is dark brown and where thoroughly oxidized, a bright red color. The conglomerate shows the effects of differential weathering, those beds offering less resistance to weathering forming hollows, and those of greater resistance, forming ridges. In places the pebbles are less numerous and the beds are mainly coarse sand. At Kennedy Ledge, to the east of Nelson Ledge, the conglomerate contains fewer pebbles and they are smaller, on the average. This is evidence that within short distances the nature of the formation changes considerably. Everywhere it shows beautiful cross-bedding,

bottomset, foreset and topset beds being common. Lamb[1] believes the Sharon Conglomerate is a stream deposit because of its position, constitution and structure. The pebbles are nearly all white, vein-quartz, occasional ones being rose-quartz or jasper. They are, without exception, well water-worn. The fact that they are all crystalline quartz, such as is found in igneous or coarsely crystalline rocks would indicate that they came from distant sources and not from Ohio or its neighboring states. The nearest coarsely crystalline rocks from which they could have been derived, were, during the Pennsylvanian period, located in the Canadian Shield to the north or the continent of Appalachia to the east. Studies made by geologists[2] indicate that the Sharon Conglomerate was laid down in troughs in the old Mississippian floor. It appears to be of marine origin, laid down in what are in some instances, broad valleys. The material apparently filled these valleys with thicknesses of from 100 to 200 feet of conglomerate. The Sharon coal, commonly known as the number 1 coal, was laid down above it. The older authorities attributed the pebbles to quartz veins in old Appalachia, but Hyde and Stout[2] tracing the streams through the short distance they are exposed along the outcrop, have the idea that they came from the northwest, from the southern part of the Canadian Shield. However the question is not a settled one and requires more work in the field for its solution.

The irregular, sharp contact of the Sharon Conglomerate with the Cuyahoga shale can be seen in Gold Hunter's Cave. Here the conglomerate appears to fill hollows on the undulating, eroded surface of the Cuyahoga. A careful study of the base of the Sharon Conglomerate, which constitutes the roof of the cave, reveals in places, pieces of flagstone, shale and cobble stones derived from the Cuyahoga, some angular, some rounded and flat and well worn, several inches thick and more than a foot long, lying in all directions and mixed with sand and pebbles.

The Sharon Conglomerate is reported to be 75 feet thick by Lamb[3] at Nelson Ledge. The writer measured its thickness at Cascade Falls with a tape and found it to be 45 feet. At the

[1]Lamb, G. F. Journal of Geology, Vol. 19, pp. 104–109, 1911.
[2]Hyde, J. E., Stout, W. Personal Communication from Stout.
[3]Lamb, G. F. Idem 1, p. 106.

Devil's Den a thickness of 49 feet was obtained. Prosser[4] reports a thickness of 150 feet based on barometer readings secured at the base of the conglomerate at Nelson Ledge and its highest outcrop on the highway east of the town of Nelson. The thickness varies because of two factors, erosion and the irregularity of the surface upon which it lies.

Economically, the Sharon Conglomerate is used in the manufacture of silica brick. The first silica bricks manufactured in the United States were made from the Sharon Conglomerate near Akron about 1875. Bricks of similar character are being made by the Niles Fire Brick Company of Niles, Ohio, the Ohio Quartz Products Company, Jackson, Ohio and the Portsmouth Refractories Company at Portsmouth, Ohio. Another company utilizing the conglomerate for refractory material is operating at Newels Ledge about three miles south of Nelson Ledge. The sized pebbles are also used extensively in water filtration plants and the fine material for sand blasting and foundry purposes.

GEOLOGICAL HISTORY[5].

For the benefit of those not familiar with the geological history of Ohio, a brief summary is included here Nothing is known of the rocks which underlie the Paleozoic strata of Ohio and little is known of the pre-Cambrian history. During the Paleozoic era the sea advanced and retreated over Ohio and sedimentary formations were laid down estimated to be over a mile thick. In Silurian time the sea became shallow and parts of it became lagoons, from which evaporation was rapid and in which mineral matter was concentrated and deposited as thick beds of gypsum and rock salt. At the close of Silurian time the Cincinnati arch in western Ohio, eastern Indiana and central Kentucky was uplifted as a broad geanticline. Toward the close of the Paleozoic era the seas shallowed in Ohio and during the Mississippian period the Waverly series of formations were laid down. They include the Bedford shale, Berea sandstone, Sunbury shale, Cuyahoga and Logan formations. Above the Logan formation and not included in the Waverly group is the Maxville limestone. At the close of the Mississippian period the seas withdrew and a

[4]Prosser, C. S. Bulletin 15, Fourth Series, Ohio Geol. Survey, p. 292.
[5]Based on Columbus Folio, No. 197.

long period of erosion ensued. The Maxville and Logan formations, if they extended over northern Ohio were completely removed by erosion and valleys from 100 to 200 feet deep were carved in the Cuyahoga formation. The unconformity marking the contact between the Cuyahoga Shale and Sharon Conglomerate of the Pennsylvanian is one of the most widespread and represents a period of erosion during which hundreds of feet of material may have been removed. During the Pennsylvanian period, eastern Ohio lay nearly at sea level, being at times submerged and receiving thin marine deposits and at other times being land, covered with vast swamps in which flourished the plants whose remains formed beds of coal. These conditions continued well into the Permian period, when the sea finally disappeared, and has never returned. At the end of the Paleozoic era a vast area which had been sea was uplifted into the Appalachian Mountains. During the Mesozoic era the Appalachian region including Ohio was beveled by erosion. This peneplane has been removed by erosion and another developed during the Tertiary era. The latter is represented by the upland in eastern and southeastern Ohio at an altitude ranging from 1,200 to 1,300 feet. This erosion surface, called the Harrisburg peneplane[6], was uplifted and dissected in Tertiary time and another surface, called the Worthington peneplane[5], developed at an average altitude of 1,000 to 1,100 feet.

In the Quaternary era great sheets of ice formed continental glaciers and spread outward from centers of accumulation in Canada. Four or perhaps five ice sheets successively invaded the territory west of the Mississippi River and at least two of them, the third or Illinoian and the last or Wisconsin, entered Ohio. At the time of greatest extent the ice covered two-thirds of the State, on the southwestern corner reaching a little beyond the Ohio River. As the ice advanced it eroded the surface more or less, accentuating the relief in some places and obliterating it in others. It picked up and carried along a great quantity of stones, clay and sand, which was in part carried away by the streams as outwash and in part deposited by the melting ice. The mantle of glacial drift left by the ice is in places several hundreds of feet thick. In areas of slight relief it has formed an entirely new surface, which bears little

[6]Ver Steeg, Karl. Erosion Surfaces of Eastern Ohio, Pan-American Geologist, Vol. LV, March-April, 1931.

or no relation to the bed rock topography, for it filled and obliterated many of the pre-glacial valleys in the old surface. During each interglacial epoch as well as since the final disappearance of the ice, a new system of drainage was established on the new surface and more or less dissected it. The preglacial drainage of the Allegheny Plateau was northwestward to the Erie Plain, but as the ice margin retreated across the State from south to north, the drainage from the melting ice at first escaped freely to the south and dissected the surface sufficiently to determine the direction and character of the drainage of the present time. After the ice had left the high ground and its margin was receding down the northerly slope to and across the Erie Plain, the drainage no longer escaped freely southward but was ponded in a series of small lakes between the ice edge and the plateau. At first these lakes discharged southward through notches in the plateau, but as the ice melted back their levels were lowered and broadened out and united to form a series of lakes that preceded the present Lake Erie. The divide between the drainage to the Ohio and that to Lake Erie was in part newly established and in part uncovered nearly everywhere along or close to the edge of the plateau. The post-glacial streams have cut down to bed-rock and made gorges in it and at other places have partly cleared out the drift-filled old valleys.

It is probable that the valley to the east of Nelson Ledge was occupied in preglacial time by a tributary which flowed northward to join the old Ohio, a large preglacial stream which flowed through the broad valley leading from Youngstown, Niles and Warren and out through what is now the valley of the Grand River to the Lake Erie lowland. The drift-fill in the lowland to the east of Nelson Ledge is from 80 to 120 feet thick.

ORIGIN AND FEATURES OF NELSON LEDGE.

In the preliminary topics we have discussed the location, drainage, topography, geologic history and stratigraphy of the area. With this background it is possible to proceed with the discussion on the scenic features at Nelson Ledge.

One of the outstanding characteristics of the Sharon Conglomerate are the well-developed joints which break the rock into great blocks. They occur in systems having definite trends. At Nelson Ledge the writer made observations on the

direction of a large number of joints and found one system with a trend of N. 35°–40° W. Another system has a direction varying from N. 10° E. to N. 30° E. most of them being N. 20° E. These two systems are nearly parallel to the cliff and are the most important. Another well-developed system runs from N. 60° to 80° W., and a few joints were recorded at about N. 65° to 70° E. There are four systems of joints, two parallel to the cliff and two which meet the others at a high angle. Such systems of widely spaced joints would tend to break the Sharon Conglomerate into huge, angular blocks. The cause for the jointing is attributed to differential stresses produced by crustal movements in the past, shrinking and settling of sediments due to loss of water incorporated in them when laid down, and the weight of the superimposed beds laid down upon them.

The tendency is for an escarpment to recede as a result of erosion. The recession is more pronounced when a hard rock formation, very resistant to erosion is underlain by a softer material. The removal of the weaker substance, commonly shale, from beneath the harder formation, a process of undermining, is known to geologists as sapping. At Niagara Falls, a similar process accounts for the retreat of the falls. At Nelson Ledge the Sharon Conglomerate, a hard, siliceous rock, very resistant to weathering and erosion is underlain by the Cuyahoga shale, five or more feet of which are exposed in Gold Hunter's Cave located beneath Cascade Falls. Here the undermining process has produced a semi-circular cavern about 80 feet long and 35 feet wide. The chief agent of erosion is Cascade Creek; it is evident that the origin of the cave is directly related to the formation of the pothole at the base of the falls. The waters of Cascade Creek, falling a distance of about 50 feet now dashes on a large boulder which fell from the cliff above and at present partly blocks the entrance to the cave. Although this rock breaks the force of the water to some extent, during heavy rains a great volume of water whirls around in the cave and further undermines the cliff It is probable that the fall of the rock is recent and that most of the undermining took place prior to its fall. Nevertheless the process is quite active at present. From the back of the cave and midway, there is a stream of water which issues from an opening in the rock. One can hear the roar of falling water somewhere to the rear and not far from the opening.

The water is falling from above through an enlarged joint in the Sharon Conglomerate. Here we have another example of how the undermining process is accomplished. The softer shale is thus removed by the work of water flowing along enlarged joints. That this process is effective can be observed at the Devil's Den and in the narrow gorge or cleft immediately to the west of it. That the undermining process takes place to some extent by underground water flowing along joint planes is further suggested by the numerous hollows and sags on the upland to the west of the cliff. Here for several hundred feet back from the escarpment the upland has the appearance of an undermined area.

There is another point in the park where similar processes of erosion have produced a cave and a deep narrow gorge. A stream, Sylvan Creek, heads in a swamp to the west of the State Park area, and after flowing eastward to a point about 50 feet east of the park boundary, dashes over Sylvan Falls into a deep narrow channel. This gorge, about 50 feet deep, has been cut along the joint planes and has an angular, zig-zag form, the result of excavation along two joint systems which meet at an angle; one system has a northwest and the other a northeast trend. So narrow is the gorge that at a point just west of the Devil's Den it is little more than a cleft in the rock, in some places not more than two or three feet wide and standing at an angle of about 70 degrees. Similar features have been produced at the Dells of the Wisconsin at Kilbourn, as a result of streams following the joints in the Potsdam sandstone of upper Cambrian age. There the Wisconsin River and its smaller tributaries have followed the joints, forming post-glacial gorges, in some places extremely narrow and angular.

At the Devil's Den, Sylvan Creek has been very effective in undermining the conglomerate. As a result the rock has fallen in and been further removed by weathering and water action. One large block at the Devil's Den, which has been undermined, is tilted and has dropped down a distance of about three feet, forming a scarp; at other points in the park where undermining has allowed blocks to settle, scarps are present. In several instances two blocks have fallen so that the tops rest together while the bases are detached forming grottoes such as Hanging Wall Cave and Old Maid's Kitchen. There are also not infrequent caves formed by joints where

FIG. 3.
Cascade Falls.

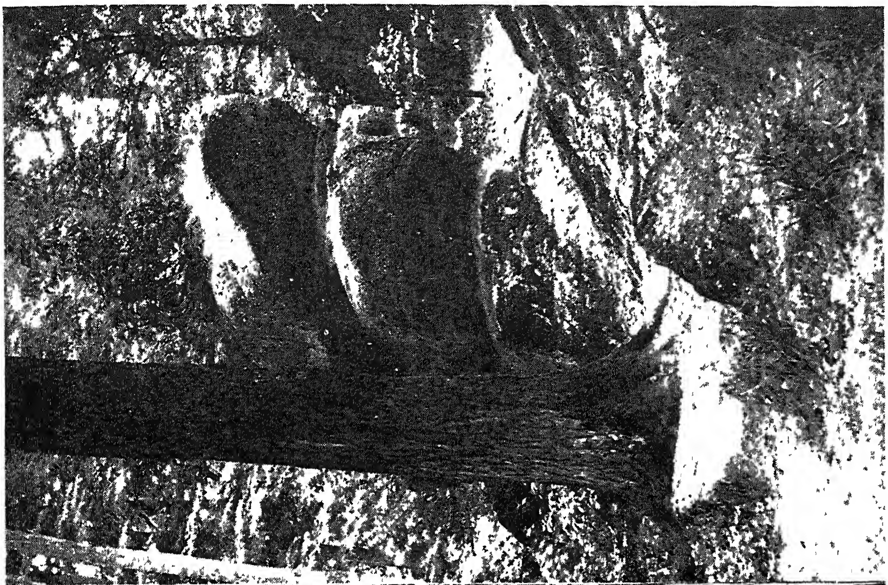


FIG. 4.
View along the trail. Sharon conglomerate well displayed.

they are roofed over by the upper layers, an excellent example being Shelf Rock Corridor. In many cases the blocks are tilted away from the cliff, producing a wide crevice at the joint plane where the break occurred. To the east of the Devil's Den there is another grotto through which flows Sylvan Creek. It measures about 40 feet from end to end and is called the Devil's Ice Box because of the low temperatures which exist, even during the warmest days of summer. Here the creek has undermined the conglomerate and produced a cave. It requires no stretch of the imagination to picture the collapse of the roof and the tilting of the block, a process which doubtless has taken place many times in the past. It is quite apparent that the undermining process has been very effective along the creeks. The great boulders are much more numerous at Cascade Falls and along Sylvan Creek, east of the Devil's Ice Box. It is obvious that the undermining process is at present taking place far back from the cliff along Sylvan Creek. The greater effectiveness of the streams in the undermining process accounts for the greater number of detached blocks of conglomerate along them. The two systems of joints, which parallel or nearly parallel the ledge face or scarp, facilitate the breaking of the blocks from the ledge after the undermining process has accomplished its work. At some distance back from the cliff, possibly a few hundreds of feet, the water is finding a way of escape by draining downward through the joint planes in the conglomerate. It is probable that the joint planes have been much enlarged by weathering and undermining. The surface is quite hummocky with many shallow depressions reminding one of an undermined area.

The most picturesque localities in the park are at those places near the creeks where the undermining process has produced many isolated blocks of rock and deep, narrow gorges. The two most interesting spots from both scenic and scientific stand-points are at Cascade Falls and along Sylvan Creek from Sylvan Falls to Temple Rocks. The picturesque trails along which are found the glens, narrow gorges and grottoes, are marked off into three routes, which combined, measure more than a mile in length.

A common misconception by the layman concerning the processes which have operated to produce the fallen blocks of rock is that a great earthquake took place at some time during the past to produce the assemblage of huge boulders standing

at all possible angles. This is not correct, for as has been pointed out in the previous discussion, a slow process of undermining by weathering and erosion is the sole cause. Some day the roof of Gold Hunter's Cave will collapse. The downward movement might be a sudden one, the impact producing a small earthquake. Minor earthquakes occur occasionally in regions where caverns or underground passages are present in limestone areas. The collapse of the roof or the fall of masses of rock from above to the floor of a cave may be the cause. Small earthquakes have occurred in the vicinity of Niagara Falls, when great blocks of undermined limestone have fallen from the brink of the falls to the gorge below.

It has been suggested that a stream to the east of Nelson Ledge accomplished the undermining responsible for the great blocks of conglomerate which lie below the cliff. It is not necessary to account for them in that manner, for it is obvious that the processes of weathering and erosion by running water are very active at present in producing the features of the park. Furthermore it is impossible to account for the undermined areas back from the ledge face by the action of a stream to the east.

A process not given much consideration so far, is that of weathering. The joints allow the ready movement of water downward from above. This water which carries oxygen and carbon dioxide, and direct contact with the air itself, accomplish changes. As a result the rock undergoes a process of chemical disintegration. Mechanical weathering takes place when the water, absorbed by the rock and filling the cracks, freezes. The expansion causes the rock to break, repeated freezing and thawing producing mechanical disintegration. By chemical and mechanical processes of weathering the joints are gradually enlarged. In some cases the debris which has fallen into the crevices from the walls above, has nearly filled them. It is probable that the hollows on the upland, back from the face of the ledge, are due mainly to the enlargement of the joints by weathering. The Sharon Conglomerate weathers differentially, the more resistant beds standing out conspicuously. One occasionally sees numerous, small, nearly circular, shallow hollows in the conglomerate where it has been exposed to weathering. The Sharon Conglomerate has a tendency to weather with rounded instead of sharply angular outcrops.

Another weathering process which has aided in rock disintegration is the result of plant growth. There are a number of large trees in the park whose roots occupy the narrow spaces or joints between the blocks of conglomerate, gradually wedging them apart. One wonders how the trees can live when their roots extend down into what appears to be barren rock. Such trees are found at a number of places in the glens such as Lundy Lane and others. In some cases the trees cling to the vertical walls of the conglomerate. Mosses, ferns, and lichens where there is sufficient moisture, cover the walls with a mass of growth. Because of the dense foliage which shades the ledge the evaporation is small, and these plants flourish in the cool, damp glens. They absorb moisture and further aid the process of weathering.

One sees in Gold Hunter's Cave and in other parts of the park, a brilliant, yellow material commonly known as ochre or limonite ($Fe_2 0_3 . 3H_2 0$). In the cave it is being precipitated from the waters of the spring which issues from the back wall of the cave. The spring doubtless obtained its iron from the Sharon Conglomerate through which it has flowed or percolated. Wherever the water issues from the conglomerate and stands for any length of time, an iridiscent scum, resembling oil forms on the surface. This scum is produced by oxidation at the surface of the water, where the iron in solution comes in contact with the oxygen in the air. Hanging from the roof of Gold Hunter's Cave are numerous, short, rounded stalactites of limonite. It is possible that the ochre results from the weathering of iron pyrite present in the Sharon Conglomerate. The water from the conglomerate, although it contains a small percentage of iron in solution, is soft, and contains little carbonate of lime and other impurities which require soap for softening.

Bacteriology.

A new and reset edition of a standard text-book on bacteriology. The older editions were among the best of their kind, and the new edition seems to live up to the high standard previously set. New material in this edition includes thorough discussions of the bacteriophage, of the role of bacteria in the arts and industries, and of the practical applications of this subject especially in regard to milk, butter and water. Other chapters have been entirely rewritten.

The same clear style and thorough treatment that characterized the older editions are apparent in this, and it will undoubtedly continue to receive the same enthusiastic welcome which it has enjoyed in the past.—S.

Elementary Bacteriology, by Joseph E. Greaves and Ethelyn O. Greaves. 535 pp., 12 mo. Philadelphia and London, W. B. Saunders Co., 1932. $3.50.

A NEW TRIGONOCARPUS FROM OHIO.

WILLARD BERRY,
Ohio State University.

In the collections of the Geological Museum of the Ohio State University there is the cast of a fossil seed that appears to be new to science. This seed is from the Upper Carboniferous (Pennsylvanian) at Steece, Lawrence County, Ohio. It was presented by E. L. Lambert through E. B. Willard and is number 10,429 in the collections. No additional information is definitely known about its history. However, Lambert was mine superintendent for Willard and they were mining the Vanport limestone at Steece. There the Vanport limestone is overlain by a sandstone. (The entrance of the mine is still open but the rest is flooded.) It is probable that the seed is from this sandstone above the Vanport limestone and below the No. 5 coal. The sandstone is the Kittanning sandstone of the Pennsylvanian Survey.

This seed-cast is rather unusual as it is much larger than most and the ribs are double, although only three in number. I have referred it to the genus *Trigonocarpus* although it may represent a species of *Radiospermum*. The presence of an opening in the base might be interpreted as where the pith entered the seed, in which case it should be referred to *Radiospermum*. However, investigation on one side of the seed where it was damaged seems to indicate lack of internal structure, therefore I have referred it to *Trigonocarpus*.

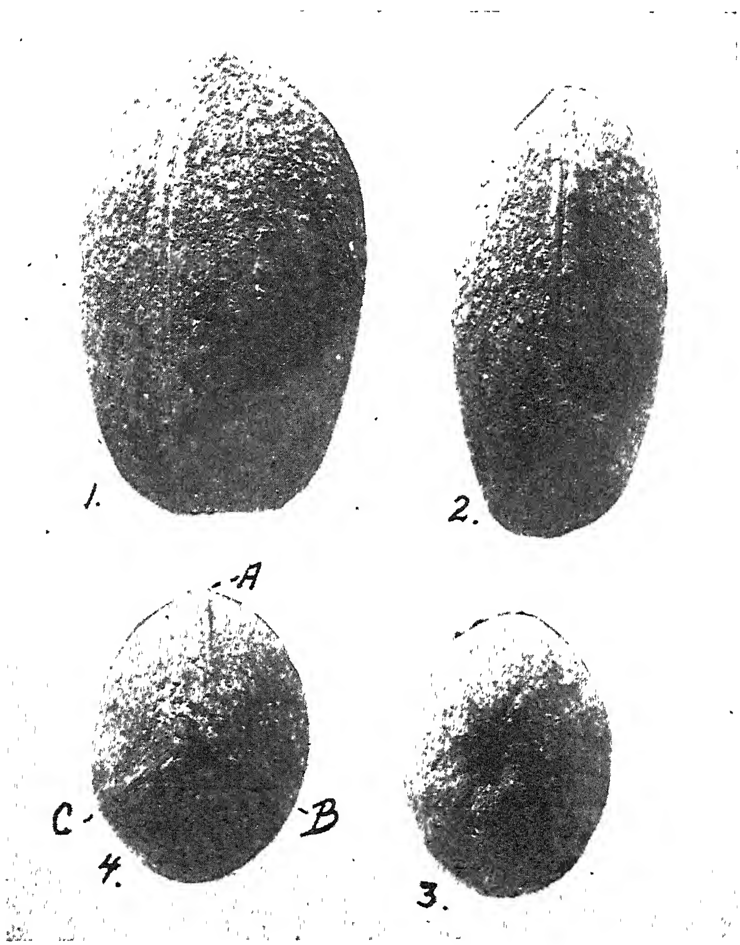
The cast is of sand with abundant ferruginous cement. The surface is composed mainly of the cement.

As far as I can ascertain it is a new species and cannot be referred to any described form. The nearest described form is *Radiospermum ovatum* (Lindley and Hutton) as described and figured by Arber, although my seed lacks structure. It may be described as follows:

Trigonocarpus steecensis W. Berry n. sp.

(Figures 1, 2, 3 and 4.)

From the side, elongate-ovoid in form, slightly broader towards the apical end. In cross section elliptical. Surface crossed from apical end to base by three prominent double ribs—A, B and C. Double rib A is composed of two ridges each about 1 mm. broad separated by a narrow groove averaging 0.5 mm. wide, from which towards the apical



Trigonocarpus steencensis W. Berry, n. sp.

Fig. 1. Side view showing rib B.
Fig. 2. Edge view showing rib A.
Fig. 3. Basal view.
Fig. 4. Apical view, double ribs A, B, C, labeled. About natural size.

end rises a narrow fin or wing, about 0.5 mm. wide and broken off elsewhere. The entire length of the groove is occupied by what appears to be the continued base of this wing. Double rib B is about 130 degrees from A, and C about 90 degrees from B. The double ribs are all alike, although the width of them may vary slightly. These double ribs rise at the base of the cast, though all but B are very faint at the base, and tranverse the surface towards the apical end, where they are lost as the apical end is not entirely preserved. About 43 degrees on either side of A is a shallow groove, the one between A and B being the most pronounced. This groove is about 2 mm. broad and 0.75 mm. deep and runs from near the base to within 2 cm. of the apical end. The groove between A and C is much less clearly marked and is slightly wider, otherwise like the first one.

Balance of the surface shows the rounded sand grains of the cast.

Apical end more or less destroyed, enough preserved to show that the double ribs came almost to it, there is just a faint suggestion that the double ribs enclosed a small "pollen chamber."

Basal end shows the three double ribs coming in towards the center, which is an irregular oval opening about 4 mm. by 2 mm. This hole penetrates about 4 mm. into the cast.

Length, 6.5 mm.; breadth, 4.4 mm.; depth, 3.5 mm.

Living Machinery.

The preparation and radio-broadcasting of a series of talks on biological principles lead to their subsequent collection and publication in book form. The result is a pleasing collection of essays covering in popular form a wide variety of subjects, all centering on biology and its modern applications. The author states that the book is designed to raise questions rather than to answer them, and it must be said that it does just this. The essays are in effect short introductions to the various subjects. The reader is apt to find that just as he thinks the author is warming up to his subject, the essay abruptly closes. However, the arousing of a desire to know more about the subjects treated is one of the best features of the book.

A few poor analogies are used, such as comparing the variability of heredity with the words possible from combinations of letters of the alphabet, in which it is forgotten that letters may be missing from words, but that one or another of each set of allelomorphs must be present in each organism of a species An occasional loose statement is found, such as the use of "morons" where obviously "cretins" was meant. Teleological statements appear freely. However, these are minor defects, and the book will provide entertaining reading not only for the layman but for the trained biologist as well. Especially good are the chapters on foods, and the one on parasitism.—L. H. S.

The Machines We Are, by Robert T. Hance. xvi+382 pp., New York, Thomas Y. Crowell Co., 1932.

STARCH SYNTHESIS IN THE VARIEGATED LEAVES OF PELARGONIUM.[1]

A. G. CHAPMAN AND W. H. CAMP.

INTRODUCTION.

Under natural conditions, the non-green portions of most variegated leaves do not synthesize starch. It has, however, been known for some time that the non-green portions of many leaves could synthesize starch if artificially supplied with glucose.

In the green leaf, the more important underlying conditions known to affect starch synthesis are: the concentration of soluble carbohydrates; the type and distribution of plastids; the activity of certain enzymes, particularly the carbohydrases; and the hydrogen-ion concentration of the cell contents.

Böhm (1883) was probably among the first to show that green leaves would synthesize starch in the chloroplasts if floated on a sugar solution in the dark. Spoehr (1926) mentions similar investigations by Meyer (1886), and others. Saposchnikoff (1889) and Borkorny (1897) also showed that starch synthesis would occur in starch-free green leaves of many species if floated on solutions of soluble carbohydrates in the dark. Miller (1931) reports that Böhm (1883), Schimper (1885), and Meyer (1886) found that starch formation occurred in chloroplasts and leucoplasts only when the solution of sugar had reached a certain concentration. Winkler (1898) concluded that when the concentration of glucose or sucrose is sufficiently high, all chloroplasts and leucoplasts, with but few exceptions, form starch. He found that the lowest concentration of sucrose which induced starch formation in most cases was 0.02 percent, the optimum 10 percent; above this the starch decreased until in a 30 percent solution of sucrose no starch was produced. Spoehr (1926) concluded that the concentration of glucose necessary for starch formation varies widely for different plants. Lundegardh (1914) claimed that the transformation of sugar to starch in cells is very complicated, and that the process depends not only upon the

[1]Papers from the Department of Botany, The Ohio State University, No. 300.

concentration of sugar in the cytoplasm, but also upon the amount of an enzyme, the concentration of which is controlled by unknown factors. Spoehr (1926), pointed out that various workers have found that plants form starch in the dark when floated on solutions of not only glucose, fructose, galactose, mannose, sucrose, and maltose, but also of such alcohols as mannitol, ducitol, erythritol, and glycerol. According to Winkler (1898), formaldehyde and an extract from natural humus may also be used.

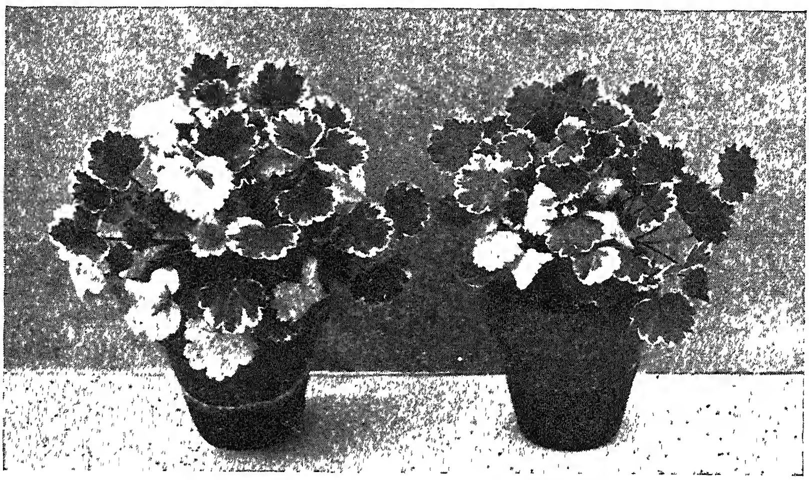


FIG. 1. *Pelargonium* plants from the clon culture used in the experiments.

A number of investigators have studied the ability of various plants to synthesize starch in the non-green portions of their leaves, and also certain of the factors which normally inhibit its formation. Winkler (1898), after unsuccessful attempts to induce starch synthesis in the white portions of the leaves of *Pandanus Veitchii*, found there were no plastids present. Hein (1926) in a review of the subject quotes Woods (1899) as believing that in *Pelargonium* and in many other cases of variegated leaves, the chlorophyll is destroyed by oxydizing enzymes, the oxidases and peroxidases, which are normally present in all green plants and under certain conditions may be produced in abnormally large quantities. He also states that Baur (1904) found that the plastids in the white cells of *Pelargonium* uniformly contain little or no chlorophyll and are smaller than the plastids in the green cells, and that

Küster (1919) concluded that the plastids in the non-green areas of *Pelargonium* are incompletely developed or have become bleached and degenerate, possibly through agencies inside the cells.

Maige (1924), studying the effect of temperature on starch formation in various leaves, found within certain limits, a correlation between the two. Henrici (1921) showed that the minimum temperature and light intensity necessary for photosynthesis are lower than those required for starch formation. Gillis (1923) thought that the formation of starch from sugar in variegated leaves depends to a certain extent on light.

The work done by the present writers was undertaken as a further study of the factors which inhibit starch formation in non-green leaf tissue under normal greenhouse conditions, and of the factors which affect the rate of starch formation when carbohydrates are supplied.

In the preliminary work, various species of variegated-leaved plants were used. The present report, however, is found in studies of the variegated geranium (*Pelargonium hortorum* var. *Mme. Salleroi*).

The writers wish to acknowledge the help of Dr. H. F. Thut of the Alabama Polytechnic Institute, who assisted in the preliminary part of the investigation.

SUGAR CONCENTRATION OF SUBSTRATE.

In this portion of the investigation, the material consisted of carefully selected *Pelargonium* leaves obtained from plants of a clon culture. (Fig. 1).

METHODS.—Mature, but active leaves from representative plants were removed with a sharp razor. The cut ends of the petioles were immediately immersed in freshly prepared glucose solutions of 0.2, 0.3, 0.4, 0.5, 0.6 and 0.7 molecular concentration.[2] A sufficient number of albino as well as variegated leaves were available for the study. Two series were made, one being placed in the dark, the other in the light, the temperature and atmospheric humidity being nearly equal in both situations.

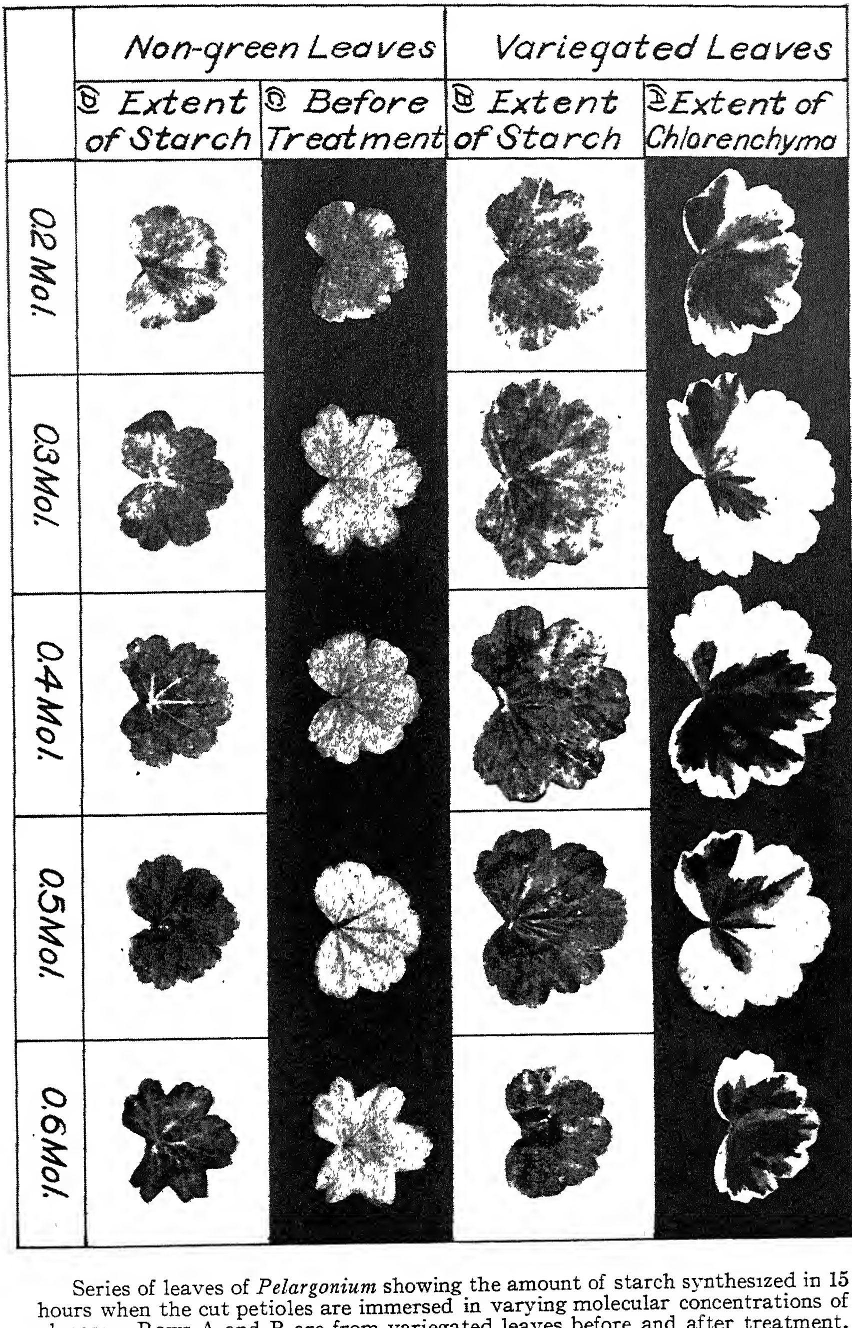
After fifteen hours, the chlorophyll was removed from the leaves by means of ethyl alcohol and starch tests made by the usual iodine method.

[2]All glucose solutions were weight molecular from C. P. material.

RESULTS.—The following results were obtained in both the variegated and albino leaves. A trace of starch was present in the leaves which were in the 0.2 molecular solutions. In the higher concentrations, the amount of starch in the leaves increased proportionately with the concentration of the glucose up to the 0.5 molecular solution. In the 0.6 molecular solution a slight decrease was noted, and only a trace of starch appeared in the 0.7 molecular solution. Slight effects of plasmyolysis were observed in a few of the leaves in the 0.6 molecular solutions; and wherever this condition was found, a noticeable decrease in the starch was observed. The small quantity of starch in the 0.7 molecular concentration probably was due to the conditions accompanying plasmolysis which was most severe in the albino portions. Non-green portions of the leaves in 0.3, 0.4, 0.5 and 0.6 molecular concentrations, except where noted for the 0.6 molecular solution, became dark violet in color on the application of the iodine solution. No great difference could be observed between the green and non-green portions of the leaves after testing; the transition line between the two portions disappeared because of the uniform distribution of the starch. (Fig. 2.)

No noticeable difference occurred in the amount of starch synthesized by leaves in the dark or in the light.

DISCUSSION.—While Winkler (1898) and others selected glucose and sucrose as the two most desirable materials for synthesizing starch in leaf tissues, they employed almost exclusively a 10 percent solution of sucrose. Winkler does not state the time required for starch formation in starch-free *Pelargonium* leaves; but for other species, the time varied from one day to three weeks. To keep the floating leaf parts as free as possible from bacteria and fungous growth, he occasionally transferred the material to fresh sugar solutions which were treated with a sufficient amount of phosphoric acid for sterilization. In many cases, there was a continuous increase of starch in the leaf tissue over a period of two to three days. This delay and comparatively long period of gradual increase might have been closely correlated with the rate of hydrolysis of sucrose in the acid solution. It has been well established by Weevers (1924) and others that starch is not synthesized directly from sucrose. It is therefore the opinion of the writers that in the earlier work, where sucrose was used as a substrate,



Series of leaves of *Pelargonium* showing the amount of starch synthesized in 15 hours when the cut petioles are immersed in varying molecular concentrations of glucose. Rows A and B are from variegated leaves before and after treatment. Rows C and D are from albino leaves.

that it was not sucrose that was used by the plant in starch synthesis but its hydrolytic products.[3]

It was known long before the investigations of Winkler (1898) that light is not necessary for starch synthesis. Yet Winkler thought that there might be an indirect influence of light upon the starch building process, such as, "a promoting of chloroplasts" and "a retarding of leucoplasts." Miller also mentions that "The formation of starch might be influenced by light in an entirely different manner from that influencing the process of photosynthesis."

The writers' results obtained from *Pelargonium* leaves in both daylight and complete darkness show no observable difference in the quantity of starch synthesized in the non-green portion. At least for this species, any indirect beneficial or deleterious effects of light, due either to intensity or quality, are probably insignificant or lie outside the range of intensity and quality of light experienced under greenhouse conditions.

SUGAR DETERMINATIONS.

As the preliminary work showed that starch synthesis would occur in the non-green portions of *Pelargonium* leaves when glucose was supplied, the following study was made to ascertain the relative amounts of sugar normally present in the several parts of the leaf.

METHODS.—Total sugar determinations were made, according to the Shaffer-Hartman method, on duplicate samples of both green and non-green portions of the same leaves. The samples were collected shortly before noon on a clear day and transferred at once to 80 percent ethyl alcohol which was soon brought to the boiling point to prevent further enzyme action. Five-tenths of a gram of calcium carbonate was also added to neutralize any acids present. The amounts of total sugars were calculated from the standard Munson-Walker tables.

As it has been established that starch may be synthesized from several of the soluble carbohydrates or their hydrolitic products, no attempt was made to differentiate between the reducing and non-reducing sugars, the results being expressed as total sugars.

RESULTS.—Expressed in the percentage of the fresh weight,

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[3]It may be noted that the writers were able to obtain starch synthesis when fructose was used as a substrate.

samples from the green portion contained 0.36% total sugars, while the albino portions contained only 0.18% total sugars.

DISCUSSION.—Analyses by the writers have shown that the total sugar content of the green tissue at mid-day was approximately twice that of the non-green part. It is generally known that there is a point of sugar-starch equilibrium above which starch formation exceeds starch hydrolysis, and that this point of equilibrium may shift with certain internal factors. The fact that starch synthesis is induced by artificially supplying glucose, leads the writers to believe that the sugar concentration and its relation to the sugar-starch equilibrium is an important factor in the lack of starch formation in the non-green leaf portions of *Pelargonium*.

FLUCTUATION IN HYDROGEN-ION CONCENTRATION.

The well-known effect of hydrogen-ion concentration on many physiological reactions prompted the writers to make a study of this factor in relation to the problem of starch synthesis. Determinations of the hydrogen-ion concentrations were made to show the changes in pH over a period of twenty-four hours.

METHODS.—In the study of the pH fluctuation over a twenty-four hour period, pots in which the plants were growing were sunk two-thirds of their depth in sand. The plants and sand were watered to insure a sufficient water supply during the course of the experiment.

Starting at 12 noon on May 26, 1931 samples of the green and non-green portions of the leaves were taken every three hours until noon the next day. Thirty-six plants, derived from a clon culture, were used. During the entire period of the experiment the sky was clear. The samples were obtained by separating the green and non-green portions of representative leaves with scissors until enough material was obtained to make a determination. Twenty-five leaves were used for each determination.

The separate samples from the two parts of the leaves were placed in one-inch, rubber-stoppered test tubes and immersed in a bath at —20 C., where they were quickly frozen. After ten minutes the samples were thawed and the juice expressed by means of a power press at a standard pressure of 2500 pounds per square inch. It was only by this method that a sufficient quantity of extract could be obtained to make a

determination. The quinhydrone potentiometer was used to find the hydrogen-ion concentration of the expressed juice. Since none of the pH values found closely approached the pH of 7.0, there was probably no decomposition of the quinhydrone sufficient to produce anomalous results.

Determinations of fluctuations in pH over a 24-hour period in the variegated coleus (*Coleus Blumeii*) were made at the same

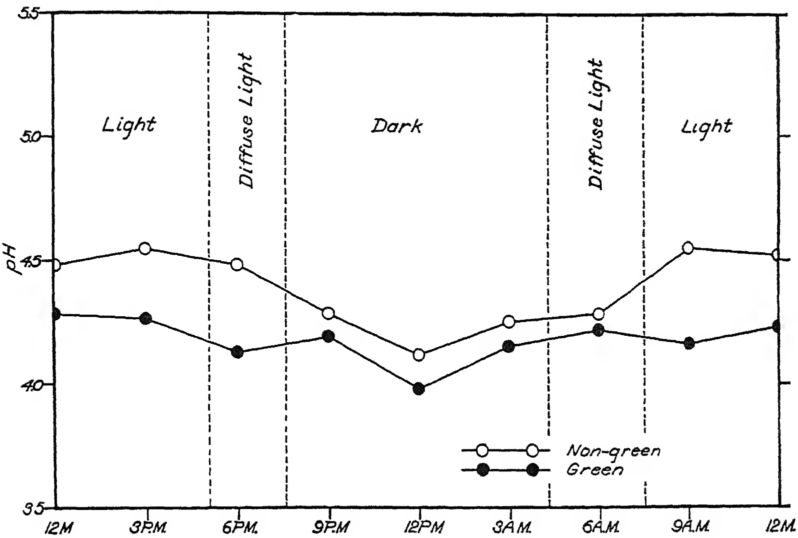


FIG. 3. Comparison of the fluctuations of the pH values in the green and non-green portions of the variegated leaves of *Pelargonium* over a 24-hour period.

time. Determinations of the relative pH of the margins and central portions of the non-variegated leaves of cabbage (*Brassica* sp.) were also made.

RESULTS.—Figure 3 shows the fluctuation in pH in the green and non-green portions of the leaves during a twenty-four hour period. It is evident that although fluctuations occur, the non-green portion of the leaves was consistently higher in pH than the green portion.

In the study of pH fluctuation in the variegated coleus it was found that the non-green inner portion of the leaf varied between 5.10 and 5.95, while in the outer green portion the pH varied between 5.85 and 6.15.

The cabbage without variegated leaves, showed a pH

value of 5.85 at the margin of the leaf and a pH value of 5.72 in the central portion.

DISCUSSION.—It is clear from the above results that the outer (non-green) portions of *Pelargonium* leaves are consistently higher in pH than the inner (green) portions. Studies of the variegated-leaved coleus, in which the position of the green and non-green areas is the reverse of those of *Pelargonium*, as well as of the entirely green leaves of cabbage, gave similar results. Freeland (1931) also found that the leaf margins of *Bryophyllum calycinum* and *B. crenatum* had a higher pH value than the central portion. These various results led the writers to believe that in the species examined the decreasing gradient of pH from the leaf margin to the center is not so much correlated with the green or non-green tissues as with their position in the leaf.

HYDROGEN-ION CONCENTRATION OF THE SUBSTRATE.

In the previous experiments on the fluctuation in H-ion concentration, the writers found a difference between the green and non-green portions of *Pelargonium* leaves. It was thought that this difference might influence the point of sugar-starch equilibrium. Therefore, a study was made to determine, if possible, whether a difference in the H-ion concentration of the substrate on which the leaves were floated would influence the formation of starch in the leaf.

METHODS.—Using oxalic acid, the writers prepared two series of non-buffered solutions having pH values of 2.7, 3.1, 3.3, 3.6, 3.8, 4.0, 4.2, 4.4, 4.7, 4.9, 5.2 and 6.1. Enough glucose was added to the solutions of one series to give a molecular concentration of 0.45. Both variegated and non-green leaves were cut into strips and floated on the solutions, some with the upper surface and others with the lower surface exposed to the air, being sure that the cut margins were in contact with the solution. The leaf portions in the series containing no sugar were exposed to the light from a 200 watt, concentrated filament bulb at a distance of two feet, for fifteen hours before being tested for starch by the usual iodine method. The second series, containing sugar, was placed in diffuse light, other conditions remaining approximately the same as those of the first series.

The pH values of the solutions were re-determined at the end of fifteen hours.

RESULTS.—Table I shows the results obtained from the above experiment. The numbers used indicate the relative amounts of starch present in the tissues at the various H-ion concentrations. The number "1" indicates a trace of starch; "6" indicates an abundance of starch.

It may be noted from the table that starch was synthesized throughout the entire range in acidity in both the green and non-green tissues of the leaf portions floated on glucose in diffuse light. In the non-green portions, the starch was most abundant near the veins and cut edges. The maximum starch formation in the non-green portions occurred at pH 4.4, while the maximum amount in the green portions occurred in the solutions having a pH of 3.8—4.0.

TABLE I.

Table indicating the relative amounts of starch found in variegated leaf portions of *Pelargonium* floated on oxalic acid solutions of different pH values; one series in diffuse light containing glucose at a 0.45 molecular concentration, the other in continuous bright light, but containing no glucose. Further explanations may be found in the text.

pH		2.7	3.1	3.3	3.6	3.8	4.0	4.2	4.4	4.7	4.9	5.2	6.1
Series with Glucose	Non-green ..	1	1	2	3	3	4	4	5	4	4	3	3
	Green . .	4	4	4	5	6	6	5	5	4	4	3	3
Series without Glucose...	Non-green ..	..	..	..	..	..	..	..	..	..	..	..	..
	Green ..	5	5	6	6	6	6	6	6	6	6	5	4

In the leaf portions of the series exposed to continuous light but having no additional glucose in the solutions, it was found that the green portions of the leaves contained abundant starch throughout almost the entire range, although starch was completely absent in the non-green portions.

Examination with the microscope revealed that while the starch grains exhibited the ordinary violet color associated with the iodine reaction, the vacuoles of the mesophyll cells of the leaves in the continuous light on the sugar-free solutions, contained a red staining substance, probably a dextrin, throughout the entire range of the experiment. The color was most intense at the ends of the series being less intense from pH 3.8 to 4.4. Neither starch nor dextrin could be detected in the non-green cells of the same leaves.

In the series floated on the sugar solutions in diffuse light, dextrin was detected in the green cells of the leaves from pH 2.7 to 3.6, and again from 4.9 to 6.0, practically no red color being detected from pH 3.8 to 4.7. In the non-green leaf portions, only a slight red color could be detected at the lower pH values, the color becoming more evident in the higher values, within the same range as that for the green portions.

At the end of the experiment it was found that little change had taken place in the pH values in either series up to 3.8, but beyond this point there was a gradual increase in the pH value of all solutions, none of them being higher than 6.2.

Discussion.—The writers are aware that they can not state the effectiveness of oxalic acid in regulating the H-ion concentration of the cell contents of tissues floated on a solution of this acid; yet it is evident that in those leaves floated on sugar solutions, the maximum starch synthesis occurred in those having a pH value near the averages for the two portions of the leaf under greenhouse conditions, that is, pH 4.4 for the non-green tissue and pH 4.0 for the green.

It is found that some form of dextrin is an intermediate stage between the monosaccharides and starch in *Pelargonium*, although between pH 3.6 and 4.9 where the dextrin was found to be low or absent, this transition stage may be passed through more quickly than at lower or higher pH values.

It is possible that the acid conditions of the various solutions might so change the permeability of the cell membranes that at the different pH values a greater or less amount of soluble carbohydrate, if available, might diffuse into the tissues and be used in starch synthesis. This possibility, however, is thought to be small in this particular experiment, for although the green portions of the leaves in the series in continuous light were gorged with starch and dextrin, at no pH value had sufficient soluble carbohydrates diffused from a green cell into an adjacent non-green cell to bring about starch synthesis.

It is suggested that the carbohydrases in the green cells are sufficiently active to almost immediately change any photosynthetic product into an insoluble form, particularly within the pH range of the normal green tissue.

Whatever the effectiveness of the oxalic acid may be in regulating the acidity of the cell contents, it is quite evident that the two tissues synthesize starch most abundantly in

a range of pH values, the point of maximum activity for the non-green being somewhat higher than that in the green.

TEMPERATURE EFFECTS.

Since the greatest amount of starch in the non-green parts was found in leaves treated in the 0.5 molecular solutions, this concentration was selected for a study of the effect of temperature on starch synthesis.

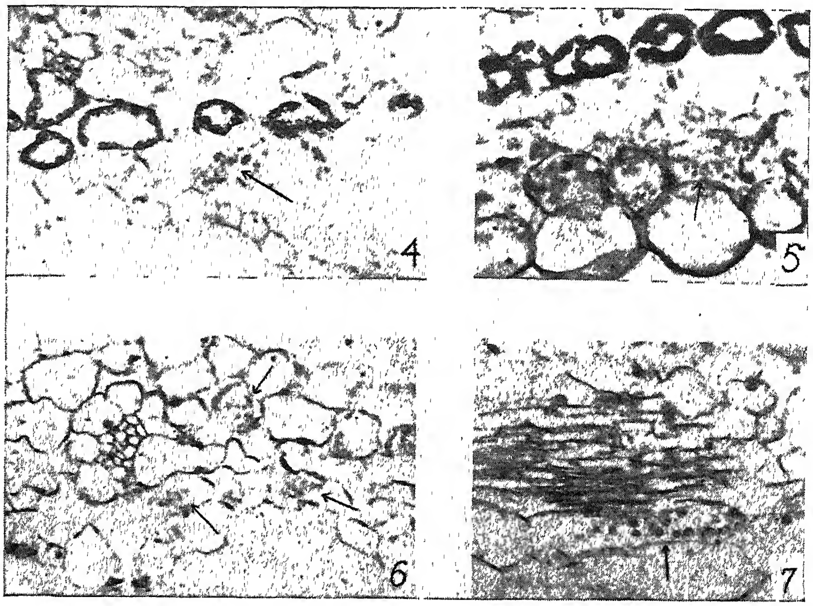
METHODS.—A series of 0.5 molecular glucose solutions, containing variegated leaves, was distributed in constant temperature chambers at 4°, 8°, 12°, 15°, 20°, 25°, 30°, 35°, 38°, 40°, 48°, and 50° C. At 38°, and above, large beakers were placed over the leaves to reduce transpiration. Starch tests were made at the end of fifteen hours. Microscopic examinations were made to detect any small quantities of starch present.

RESULTS.—A few of the leaves from the 4° C., chamber revealed a trace of starch in the cells of the albino mesophyll. Most of the leaves from the 8° C. chamber had a trace of starch, and all of the leaves from the 12° C., chamber showed a small quantity, yet a decided increase over the preceding. A very noticeable, steady increase of starch with increase of temperature appeared until a maximum was reached at 25° to 38° C. At these temperatures, the non-green portions were gorged with starch. Above 38° C., the amount of starch synthesized decreased until only a trace was found in a small number of leaves at 50° C.

DISCUSSION.—It has been recognized since the work of Böhm (1883) that temperature has an appreciable effect upon the amount of starch synthesized in leaf parts floated on sugar solutions. Winkler (1898) reported starch formation in treated leaf tissues of various species over a range of temperatures from 1° to 45° C., stating that the optimum range for most plants lay between 10° and 20° C. In the temperatures above 20° C., he found no further increase in starch.

Using a 0.5 molecular solution of glucose, the writers observed that the greatest yield of starch in the white parts of *Pelargonium* leaves occurred in those exposed to temperatures between 25° and 38° C. It should be remembered in comparing the present work with that of Winkler that he used the methods of Böhm and Meyer in his studies, that is, floating cut portions of leaves on sucrose solutions, while the writers

inserted the cut petioles in the solution. It might be that this difference in technique would produce slightly different results, but it is the opinion of the writers, based upon the preliminary studies where both methods were tried, that the difference is negligible.



FIGS. 4, 5, 6, 7. Cross-sections of the leaves of the variegated *Pelargonium*.
4, 5. Sections through the light-green areas showing the single celled layer of chlorenchyma, the large chloroplasts in the green cells, and the small leucoplasts in the non-green cells.
6. Section of the albino portion showing the weakly developed leucoplasts.
7. Section of an albino leaf near a vascular bundle, after several hours in a glucose solution, showing the early development of starch in the leucoplasts near the phloem. Arrows mark cells containing particularly well defined leucoplasts.

PLASTIDS.

In the variegated leaves of *Pelargonium*, there may be noted three distinct zones, green, light-green, and non-green. The writers made certain cytological studies to ascertain the distributional and structural differences of the plastids in these regions.

MATERIALS AND METHODS.—The material for this part of the work was taken from plants of the same clon culture as

that used in the physiological studies. Both fresh and killed material was examined. The fresh material was cut by hand and mounted either in water or a weak iodine solution. In the special preparations the material was killed in several fixatives. It was found, however, that an alcohol, corrosive sublimate, acetic acid, formaldehyde mixture gave the best results.

The pieces of leaf to be examined were imbeded in paraffin and sectioned in the usual way at thicknesses varying from 5 to 15 microns, and stained in Haidenhain's haematoxylin, according to the modified technique of one of the writers (Camp, 1931).

Owing to the difficulty of cutting sufficiently thin sections from leaves containing the large starch grains which occur in the non-green portion after treatment, the best preparations were obtained from material which was fairly free from starch.

Results.—In the dark-green portions of the leaves, the chloroplasts were generally distributed in the cells of the spongy and palisade layers of the mesophyll, occasional cell layers being free of them. The light-green areas of the leaf generally contained but one layer of cells with chloroplasts (Figs. 4, 5), while the mesophyll cells of the non-green portions were free of them.

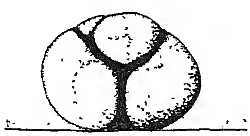
In the non-green portions of leaves which were not treated and which did not contain starch, small leucoplasts were found imbedded in the cytoplasm.

With the killing reagents and stain used, the plastids in the green portions of the leaves stood out very clearly, while those in the non-green portions were poorly defined, often appearing only as slightly denser masses of cytoplasm.

The two types of plastids differed greatly in their structure. The chloroplasts were somewhat uniform in size and shape, appearing as slightly lobed, spheroid structures (Fig. 8). Sections through the chloroplasts showed that they were vacuolate and contained 3 to 5 well defined chambers, supported and partially divided by deeply stained trabeculae which were much thicker than the plastid wall or membrane. Very minute branched strands also connected the trabeculae, but apparently were not a part of the primary structure of the plastid, although in a considerable number of plastids they seemed to have a definite arrangement in relation to the trabeculae (Fig. 9).

In contrast, the leucoplasts occurring in the starch-free, non-green portion showed no internal structure, appearing as irregularly sized, flattened granular masses or plates in the cytoplasm (Figs. 10, 11).

The leucoplasts were difficult to locate in fresh material, and even in the stained preparations were often poorly differentiated from the cytoplasm (Figs. 4, 5, 6, 10). The larger leucoplasts often showed several darker staining groups of granules within. Irregular, elongated and deeply stained bodies resembling chondriosomes also occurred in the cytoplasm of the non-green cells.



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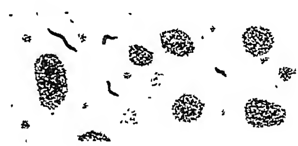

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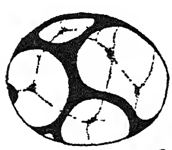

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FIGS. 8, 9, 10, 11, 12. Plastids in the green mesophyll and leucoplasts and starch grains in the albino mesophyll of *Pelargonium*. (× 2300.)
8. External appearance of the chloroplast.
9. Internal structure of a starch-free chloroplast showing the trabeculae.
10. Surface view of starch-free leucoplasts showing the associated granules and chondriosome-like bodies.
11. Side view of starch-free leucoplasts.
12. Developed starch grain showing the cap-like leucoplast.

The two types of plastids were further contrasted in the manner in which they formed starch grains. In the chloroplasts starch was found in the chambers within the plastids, the number of grains corresponding to the number of chambers in the plastid.

In the leucoplasts, the starch is apparently synthesized on one side or face of the plastid, the starch grain, after considerable

growth, appearing roughly elliptic in outline, the plastid body forming a cap at the end of the grain (Fig. 12). If a plastid membrane is present around the mature starch grain, it is too thin to be detected.

While most of the starch grains in the non-green tissue were roughly elliptic in outline, some of them were irregularly shaped. Compound grains were fairly common, originating either in a single large, irregularly-shaped plastid with several centers of activity or by the crowding and coalescing of the grains from a group of closely associated small plastids.

Evidence gleaned from relative staining reactions, optical activity, and behavior at different temperatures, indicated that the starch formed by the chloroplasts and the leucoplasts is somewhat different.

No evidence of a gradual transition from the normal chloroplasts to the leucoplast was found, the two occurring in their extreme forms in adjacent cells. Nor could any evidence be obtained from the material examined to substantiate the claim of some writers that the leucoplasts of *Pelargonium* are degenerate chloroplasts. A study of etiolated and physiologically disorganized leaves did reveal a gradual break-down and degeneration of the chloroplast, but so far as the writers were able to ascertain they did not become transformed into leucoplasts.

Discussion.—It is generally accepted at present that the plastids of many of the higher plants originate in chondriosome-like proplastids which occur in the meristematic cells. While the writers made no special study of this matter, it has been shown by several investigators (see Schürhoff 1924) that *Pelargonium* is no exception.

The problem of the origin of the two types of plastids is a difficult one to solve for there are undoubtedly a number of factors which influence their development. If both chloroplasts and leucoplasts arise from the same type of plastid primordia, there must be some factor or group of factors operating during the process of differentiation producing the two plastid types. Whatever the factors are that bring about the differentiation, they operate within a very narrow band of physiological activity, for immediately adjacent cells contain chloroplasts or leucoplasts in their extreme forms, and at no time could transition or intermediate plastid types be found.

It is also shown by sections of very young leaves that the differentiation takes place early.

Although it is well known that leucoplasts at certain times may form chlorophyll and function as chloroplasts, no evidence that this is true was found in *Pelargonium*, the variegated areas of the leaves remaining the same from the early stages until senility.

An examination of a single plant gives ample evidence that the differentiation is due to a set of factors which are more effective at one time than at another, for certain leaves will show but little variegation, only a thin margin of non-green tissue being in evidence, while other leaves may be almost entirely white.

The writers' observations indicate that light intensity affects the internal conditions influencing differentiation, for plants grown in bright sunlight tend to have but little non-green tissue, while those grown at the same temperature and humidity, but at a lower light intensity, have leaves with more non-green tissue. Individual leaves occasionally approach an almost complete albino condition.

It is also probable that the physiological gradients of the developing leaf are a factor, for the non-green portion is invariably at the margin of the leaf, and if only a small amount of chlorenchyma is present, it is near the base of one or more of the large veins of the leaf blade.

That the variegated habit is also hereditary has been shown by Baur (ref. in Schürhoff 1924), for crosses between green and variegated plants of *Pelargonium* gave variegated and non-variegated segregates in succeeding generations.

The plastids are morphologically differentiated, for the chloroplasts are irregular spheroids made up of 3 to 5 chambers, the starch, when formed, being deposited within the chambers. The leucoplasts, when starch-free, are discoid structures, often irregular in outline and sometimes optically but poorly differentiated from the granular cytoplasm. When formed, the starch is deposited by one face of the leucoplast, the active portion forming a cap over the end of the starch grain.

Haberlandt (1914) and Zirkle (1926) have shown that this type of starch-forming plastid is vacuolate, the starch grain arising internally and bursting through the plastid after growth. Although some evidence of this could be found in the leucoplasts of the material examined during the first stages of starch

formation (Fig. 7), it is to be remembered that later, only one face of the plastid is ordinarily active, the starch accumulating at the face of the greatest activity.

Reichert (1913) pointed out that starches differ greatly in their physical and chemical properties, and although no extended study of this point has been made by the writers, there were indications that the starches formed by the chloroplasts and leucoplasts of *Pelargonium* differ in their optical properties, iodine reaction, and probably in their gelatinization temperature.

CONCLUSIONS.

In the study of the synthesis of starch in the green and non-green portions of the leaves of the variegated pelargonium (*Pelargonium hortorum* var. *Mme. Salleroi*), the writers came to the following conclusions:

1. Starch synthesis normally does not occur in the non-green portion of the *Pelargonium* leaf, but will occur if the leaf is placed in a solution of glucose, the optimum point for starch formation being approximately a 0.5 molecular concentration.

2. Under normal conditions in the greenhouse, the green tissue contains approximately twice as much sugar as the non-green tissue.

3. Although the non-green tissue of the leaf consistently has a higher pH value than the green tissue, it is thought from comparative studies of *Pelargonium* and other leaves that this condition is not so much correlated with the type of tissue as with its position in the leaf.

4. Cut portions of the leaves, when floated on sugar free oxalic acid solutions of pH values ranging from 2.7 to 6.1 and exposed to fifteen hours of continuous light, synthesize starch in the green tissue; and although the carbohydrates were abundant in the green tissue, no evidence of starch synthesis could be found in the non-green portions. Since at none of the pH values could starch be found in the non-green portions, it is probable that in this type of experiment and under normal conditions in the leaf, the carbohydrases present in the green cells, by hastening the condensation of the photosynthetic products, keep the concentration of soluble carbohydrates in the green cell very low. The sugar in the adjacent non-green cells, in equilibrium with that in the green cells, is, therefore,

still below the threshold for starch synthesis for that type of tissue.

5. When cut portions of the leaves are floated on oxalic acid solutions containing glucose of pH values ranging from 2.7 to 6.1, and exposed to diffuse light, starch is synthesized in both the green and non-green portions; and since the starch is most abundant along the veins and cut edges, this indicates that each portion may independently synthesize starch when supplied with glucose.

6. The pH value of the normal tissue is not the limiting factor in the lack of starch synthesis in the albino portion under greenhouse conditions for the greatest amount of starch is synthesized by the non-green tissue when floated on a glucose solution with a pH value of 4.4, the value for this tissue under normal conditions.

7. When glucose is artificially supplied, starch is synthesized equally well in the green and non-green portions of the leaf at temperatures ranging from 4° to 50° C., indicating that temperature is not a factor in the lack of starch synthesis in the non-green portion of the leaves.

8. The chloroplasts of the green tissue and leucoplasts of the non-green tissue are differentiated in the young leaf while in the primordial condition, nor is evidence found of intermediate or transitional forms to indicate that the leucoplasts are merely degenerate chloroplasts.

9. Although the leucoplasts and the chloroplasts are morphologically different, they are both able to synthesize starch if supplied with glucose.

10. Although there are a number of factors which influence starch synthesis in the non-green portion of the *Pelargonium* leaf, the factors probably directly responsible for the absence of starch under greenhouse conditions are the low concentration of soluble carbohydrates in this tissue and the different points of sugar-starch equilibrium in the green and non-green cells.

LITERATURE CITED.

Baur, E. 1904. Zur Aetiologie der Infektiosen Panachierung. Ber. Deutch. Bot. Gesell. **22**: 453–460.

Bohm, J. 1883. Über Stärkebildung aus Zucker. Bot. Zeit. **41**: 33–38, 49–54.

Bokorny, T. 1897. Über die organische Ernahrung gruen Pflanzen und irhe Bedeutung in der Natur. Biol. Centralbl. **17**: 1–20, 33–48.

Camp, W. H. 1931. Rapidly ripened haematoxylin and its uses. Science **74**: 661–662.

Freeland, R. O. 1931. Physico-chemical changes during the regeneration of bryophyllum. Thesis. Ohio State University, Columbus.

Gillis, J. 1923. Zetmeelvorming bij Spirogyra onder den invloed van organische stoffen, Natuurwetensch. Tijdschr. **5**: 118–121

Haberlandt, G. 1914. "Physiological plant anatomy." (Eng. trans.). MacMillan and Company, London.

Hein, Illo. 1926. Changes in plastids in variegated plants. Bull. Torrey Bot. Club, **53**: 411–418.

Henrici, Marguerite. 1921. Zweigipflige Assimilationskurver. Mit spezieller Berucksichtigung der Photosynthese von alpinen phanerogamen Schattpflanzen und Flechten. Verhandl. d. nat.-forsch. Ges. Basel, **32**: 107–171.

Kuster, E. 1919. Über weissrandigs Blätter und andere Formen der Buntblattrigkeit. Biol. Zentralbl. **39**: 212–251, f. 1–27.

Lundegardh, H. 1914. Einige Bedingungen der Bildung und Auflösung der Stärke. Ein Beitrag zur Theorie des Kohlenhydratstoffwechsels. Jahrb. f. wiss. Bot. **53**: 421–463.

Maige, A. 1924. Variations du seuil de condensation amylogene avec la temperature. Comp. rend. soc. biol. **90**: 685–687.

Meyer, A. 1886. Bildung der Stärkekorner in den Laubblättern aus Zuckerarten, Mannit und Glycerin. Bot. Zeit. **44**: 81–88, 104–113, 129–137, 145–151.

Miller, E. C. 1931. "Plant physiology." McGraw Hill, New York.

Reichert, E. T. 1913. The differentiation and specificity of starch in relation to genera, species, etc. Carnegie Inst. Washington, Publ. 173, Washington, D. C.

Saposchnikoff, W. 1889. Die Starkebildung aus Zucker in den Laubblättern. Ber. deut. bot. Ges. **7**: 259.

Schimper, A. F. W. 1885. Uber die Bildung und Wanderung der Kohlenhydrate in den Laubblattern. Bot. Zeit. **43**: 737–743, 753–763, 769–787.

Schuroff, P. N. 1924. "Die Plastiden." Hand. der Pflanzenanat. Band 1. Berlin.

Spoehr, H. A. 1926. "Photosynthesis." Chem. Catalog Co., New York.

Stiles, W. 1925. "Photosynthesis." Longmans, Green and Co., New York.

Weevers, T. 1924. The first carbohydrates that originate during the assimilatory process. A physiological study with variegated leaves. Proc. Kon. Akad. Wetensch. Amsterdam. (Eng. trans.), **27**: 1–11.

Winkler, Hans. 1898. Untersuchgen uber die Stärkebildung in den verschiedenartigen Chromatophoren. Jahrb. f. wiss. Bot. **32**: 525–556.

Woods, A. F. 1899. The destruction of chlorophyll by oxidizing enzymes. Centralbl. Bakt. 2 Abt. **5**: 745–754.

Zirkle, Conway. 1926. The structure of chloroptasts in certain higher plants. Amer. Jour. Bot. **13**: 301–341.

THE REACTIONS OF CERTAIN CLADOCERA TO COLORED LIGHTS OF EQUAL INTENSITY.

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I. INTRODUCTION.

It is well known that cladocera are, at most times, sensitive to light. This fact has given rise to a number of investigations on the relative sensitivity of these animals to light of different wave-lengths.

Experiments of this nature were first performed by Bert (1869). He exposed Daphnia to light from different portions of an electric light spectrum, and found that the animals gathered most rapidly in the green and yellow-green, although they were positive to all colors. Similar results were obtained by Lubbock (1881), Hess (1910), Loeb and Maxwell (1910), Ewald (1914), and Borowski (1927). All these investigators used colored lights produced by a prismatic spectrum, although Lubbock and Ewald also employed colored filters.

Yerkes (1900) found that *Simocephalus vetulus* gathered in the yellow of a Welsbach burner prismatic spectrum, but that when a triangular prism containing India ink was placed between the source of light and the animals, so that the intensity of the red end of the spectrum was cut down to a much greater extent than that of the violet, they tended to aggregate in the blue and violet.

v. Frisch and Kupelweiser (1913), working with Daphnia, found that the animals, which became negative when the light intensity was decreased, and positive when it was increased, were positive to green, yellow, and red, although the intensity was raised, and negative to violet, blue, and blue-green, although the intensity was decreased. Similarly, Becher (1921), using colored solutions, found that *Daphnia magna* was positive to green, yellow, and red, and negative to blue and violet. Koehler (1921) obtained similar results with isolated portions of a prismatic spectrum.

Peters (1926), using a method similar to that of Becher, carried out investigations on a number of species of cladocera. For most of the species he obtained results similar to Becher's.

Scapholeberis mucronata and *Peracantha truncata*, on the other hand, were found to be positive to blue and negative to other colors.

The results obtained by these investigators agree fairly well, but their methods are, in certain respects, subject to criticism. In most cases the apparatus was neither standardized nor calibrated. Various sources of light were used. Often the wave-length transmissions of the colors used were not known. The most common fault was that of ignoring the effect of intensity, and ascribing the effects of colors to wave-length alone.

In order to ascertain quantitatively the relative stimulating effect of different wave-lengths on an organism, it is necessary to eliminate any effects which may be due to differences in intensity, either by making a correction in the results for such differences (Mast, 1917), or by using colors of equal intensity (Visscher and Luce, 1928). In none of the experiments on cladocera were either of these methods used.

The present investigation was undertaken with the object of making a comparative study of the stimulating effect of colored lights of equal intensity on certain species of cladocera.

The author is indebted to Dr. J. P. Visscher, who suggested this investigation, for his helpful suggestions and advice during the course of the work.

II. MATERIALS AND METHODS.

1. *Selections of animals for experiments:*

Investigations were carried out on the following four species: *Daphnia pulex*, *Daphnia magna*, *Moina brachiata* and *Leptodora kindtii*.

Daphnia pulex and *Moina brachiata* were collected in ponds in the vicinity of Cleveland. They were raised in the laboratory in a culture medium made up of unicellular forms of algae growing in Moore's solution, which was made up according to the following formula:

Distilled water	1 liter
NH_4NO_3	0.5 gms.
$KH_2 PO_4$	0.2 "
$Mg SO_4$	0.2 "
$Ca C_{12}$	0.1 "
$Fe SO_4$ (1% soln.)	10 minims

The formula for this culture medium was taken, with some modification, from one originally used by Klugh (1927).

It is well known that the cladocera normally reproduce parthenogenetically. The eggs are laid in a brood chamber situated between the carapace and dorsal body wall. Here they remain until they are released, producing young animals which are like the adults in appearance. Consequently, it was an easy matter to obtain animals which were not only of the same age, but also alike in genetic constitution. The proceedure was as follows: The individuals of a single brood of young were isolated. When these reached maturity, and produced young, the successive broods were separated. These were used in experiments within twenty-four hours after the first brood had been released. Only females were used, the males being discarded in the few instances in which they occurred.

Specimens of *Daphnia magna* were obtained from a clone derived from a stock kept by Banta at Brown University, and were grown in a manure infusion, made by steeping manure in tap water for a few days, and then straining through several layers of cheesecloth (Banta, 1921). Animals were selected for use in experiments in the same manner as with *Daphnia pulex* and *Moina brachiata*.

The work on *Leptodora kindtii* was done at Franz Theodore Stone Laboratory, at Put-in-Bay, Ohio, in the first week of August, 1931. This species was fairly numerous in bottom tows made in the lake with a number twelve mesh tow net. It was found that the animals could not be kept in the laboratory for more than two or three days, so collections were made every morning, and the animals used the same day. Only adult females were used; these could be readily distinguished by the presence of a brood chamber.

It is desirable, during the course of experiments with colored lights, to keep the animals in a colorless culture medium. Since the medium used for *Daphnia pulex* and *Moina brachiata* was slightly green in color, and that used for *Daphnia magna* was brown, it was necessary to transfer the animals to another medium. A satisfactory one was obtained by filtering the original algal medium, so that practically all the algae were removed. To this the animals were transferred several hours before the experiment. For Leptodora, filtered lake water was used.

Although the animals grown in the laboratory were not kept at a constant temperature, their growth-rate was fairly

constant. *Daphnia pulex* released the first brood of young in seven to eight days, *Moina brachiata* in five to six days, and *Daphnia magna* in twelve to thirteen days. The temperature at which the experiments were performed varied between 19.5° C. and 21.5° C. The temperature of the dark room used in the work with *Leptodora kindtii* was somewhat higher, varying between 25.5° C. and 26.5° C.

2. *Apparatus:*

The apparatus used in these experiments is essentially the same as that used by Visscher and Luce (1928). In fact, the lamps and filters used in this work, which were generously loaned to me by Dr. J. P. Visscher, are the identical ones used in their investigations. Since these are fully described in their paper, only a brief description will be given here.

Thirteen filters were used, of which eight were Corning glass filters, and five Wratten filters. They are listed in Table I, together with their spectral transmissions, dominant wave-lengths, and relative energy transmissions, as given by the distance at which the lamp must be placed for each filter to make the energies equal.

It will be noted that the first three filters in the series transmit some red. It is impossible to obtain a filter for the ultra-violet end of the spectrum, which does not transmit some red. There is no way of blocking out this red, without also blocking out some of the blue or ultra-violet. Since the amount of red transmitted is relatively small, it was decided best to use the filters as they were, and attempt a correction for the red later. This correction was made by determining the percentage of red transmitted, and deducting that from the total value obtained in the experiments.

The lamp used was a 100 watt, 115 volt, gas filled Mazda lamp, which carried, during experiments, the regular city current of 110 volts. The infra-red rays were absorbed by a copper sulfate filter two centimeters thick, and filled with a solution consisting of 57 grams of copper sulfate in two liters of water.

The apparatus was set up as shown in Figure 1. The lamp was enclosed in a light-proof box, with an opening about 5 centimeters in diameter. A copper sulfate cell was placed in front of the opening. The box was movable, and mounted on a track. The aquarium in which the animals were placed

was 40 millimeters square, and 20 millimeters deep, and made of a high grade of slide glass, cemented together with De-Khotinsky cement. A line was marked across the bottom, dividing it into halves, one half toward the source of light, the other away from it. The aquarium was mounted on a stand containing a small microscope lamp, which could be used to light the aquarium from below, thus facilitating the counting of the animals. Between the lamp and the aquarium was

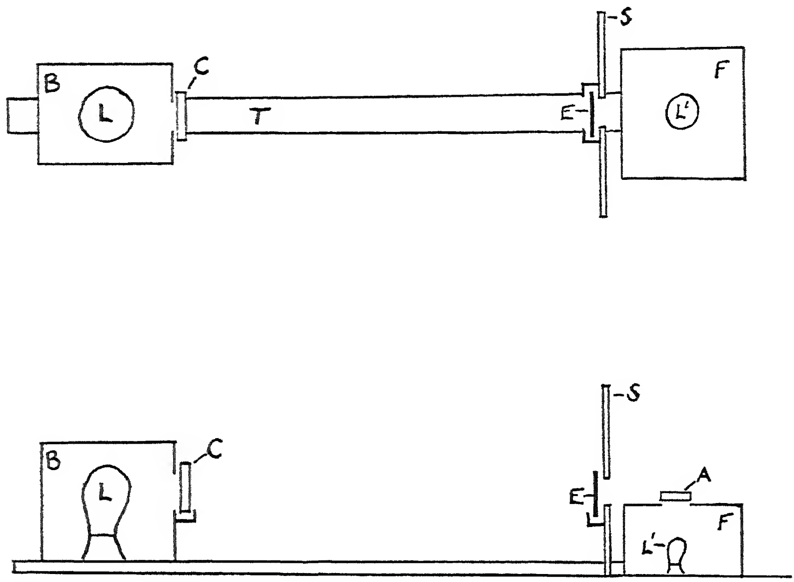

FIGURE 1. Diagrams to illustrate the apparatus used in the experiments. T, track for box (B) containing lamp (L). C, copper sulphate filter in front of opening in box. S, screen holding filters (E). F, aquarium stand containing microscope lamp (L′). A, aquarium.

placed a screen, containing an opening 5 centimeters in diameter, and a slot for the filters. The screen, stand, and lamp box were covered with heavy black paper, and the entire apparatus set up in a dark room.

3. *Method:*

When exposed to white light, *Daphnia pulex* and *Moina brachiata* were found to be neutral, and *Daphnia magna* and *Leptodora kindtii* negative. It was found, however, that they became positive when exposed to certain monochromatic lights. The method used in the experiments is based on this observation.

In carrying out an experiment, a number of animals from a single brood, usually about ten, were placed in the aquarium, and left for several hours in the dark room, to allow them to become dark adapted. They were then exposed to light. They were given three exposures of one minute each (two minutes in the case of *Daphnia pulex*) to each filter, with the

TABLE I.*

LIST OF FILTERS USED, SHOWING THEIR TOTAL SPECTRAL TRANSMISSION, DOMINANT WAVE-LENGTHS, AND THE DISTANCE OF LAMP FROM AQUARIUM FOR EACH.

Filter	Total Transmission	Dominant Wave-Length	Distance of Lamp from Aquarium
Ultra C83	315–428 $\mu\mu$ 609–Red End	355 $\mu\mu$	24.9 cm.
Purple C69	310–485 $\mu\mu$ 690–Red End	370 $\mu\mu$	42.4 cm.
Purple W35	300–475 $\mu\mu$ 650–700 $\mu\mu$	420 $\mu\mu$	44.4 cm.
Blue W49	400–510 $\mu\mu$	440 $\mu\mu$	52.6 cm.
Blue C60	335–640 $\mu\mu$	460 $\mu\mu$	81.5 cm.
Blue C59	335–690 $\mu\mu$	480 $\mu\mu$	93.2 cm.
Blue-green C56	340–700 $\mu\mu$	505 $\mu\mu$	100 cm.
Green C52	425–670 $\mu\mu$	530 $\mu\mu$	65.6 cm.
Green W58	485–635 $\mu\mu$	540 $\mu\mu$	63.2 cm.
Yellow W15	500–700 $\mu\mu$	590 $\mu\mu$	102.3 cm.
Orange W22	545–700 $\mu\mu$	620 $\mu\mu$	83.0 cm.
Orange C38	540–Red End	640 $\mu\mu$	77.3 cm.
Red C19	620–Red End	700 $\mu\mu$	49.2 cm.
White Light	....	....	119.2 cm.

The letter "C" after a filter denotes a Corning glass filter. The number after the Corning Glasses refer to the transmission curves shown in Bureau of Staudards Technologic paper 148. The letter "W" denotes a Wratten filter, and the number refers to the transmission curves found in the booklet, "Wratten Filters," published by the Eastman Kodak Company.

*All but the last column of this table is taken from Visscher and Luce (1928).

lamp placed at the proper distance (see Table I). A dark period of twenty seconds was allowed between exposures. In each case, the number of animals in the half of the aquarium toward the light was counted.

It was found that the animals became more positive to light after a series of experiments than they had been at the start. The reaction to the colors, however, was the same, regardless of the order in which they were used. That is, the reaction to a given filter was the same whether it was used at the beginning or at the end of a set of experiments.

III. RESULTS.

In Table II are given the results of several series of experiments on *Moina brachiata*. Tables III, IV, and V give results similarly obtained for *Leptodora kindtii*, *Daphnia magna*, and *Daphnia pulex*. These results are shown more graphically in Figure 2. It is immediately evident from the curves in this

TABLE II.

RESULTS OF EXPERIMENTS TO DETERMINE THE DISTRIBUTION OF STIMULATING EFFICIENCY AMONG DIFFERENT PORTIONS OF THE SPECTRUM OF EQUAL ENERGY CONTENT, FOR MONIA BRACHIATA. THE FIGURES GIVEN IN EACH SET OF EXPERIMENTS ARE THE TOTAL NUMBERS OF ANIMALS POSITIVE TO EACH LIGHT IN THREE EXPOSURES.

Moina brachiata.

Average temp. = 21.0° C.

Experiments	Animals per Experiment	Filters												
		C83	C69	W35	W49	C60	C59	C56	C52	W58	W15	W22	C38	C19
1 . . .	7 animals	3	8	12	12	14	13	12	17	17	10	12	20	12
2. . . .	5 "	1	3	2	6	4	4	6	9	13	13	13	14	10
3.	11 "	13	19	21	23	14	16	18	21	20	15	14	14	11
4.	10 "	14	14	12	19	14	12	15	17	20	19	21	20	15
5.	10 "	10	16	16	20	16	19	12	19	20	14	17	17	11
6.	12 "	18	12	22	20	19	22	27	28	26	22	30	28	20
7. . . .	12 "	20	16	21	17	16	18	16	14	9	15	15	17	8
8	12 "	15	16	21	13	14	16	15	20	19	18	15	17	10
9.	10 "	27	28	26	26	26	27	25	26	28	28	24	28	21
10.	11 "	10	13	9	12	13	12	16	17	20	17	18	16	19
Total. .	100 animals	131	145	162	168	150	159	162	188	192	171	178	191	137
Percent positive	. . . .	43.7	48.3	54.0	56.0	50.0	53.0	54.0	62.7	64.0	57.0	59.3	63.7	46.3
Corrected for Red	. . . .	42.5	46.8	52.4										

figure that the red end of the spectrum is greater in stimulating effect than the blue end. The maximum is in the orange, at about 640μμ for *Daphnia pulex* and *Leptodora kindtii*, and at about 620μμ for *Daphnia magna*. In the case of *Moina brachiata*, there are two maxima of equal efficiency, one in the green at about 540μμ and the other in the orange at about 640μμ. There is also a secondary maximum in the blue at about 440μμ, not very pronounced for *Leptodora kindtii*, but more definite for the other forms.

It is interesting to note that although the distribution of stimulating effect is similar in these forms, there are differences in the curves for each species. Those for *Daphnia pulex* and *Leptodora kindtii* are most alike. That for *Daphnia magna* differs from these in that the maximum is slightly different, and that the stimulating effect of green is relatively less. While

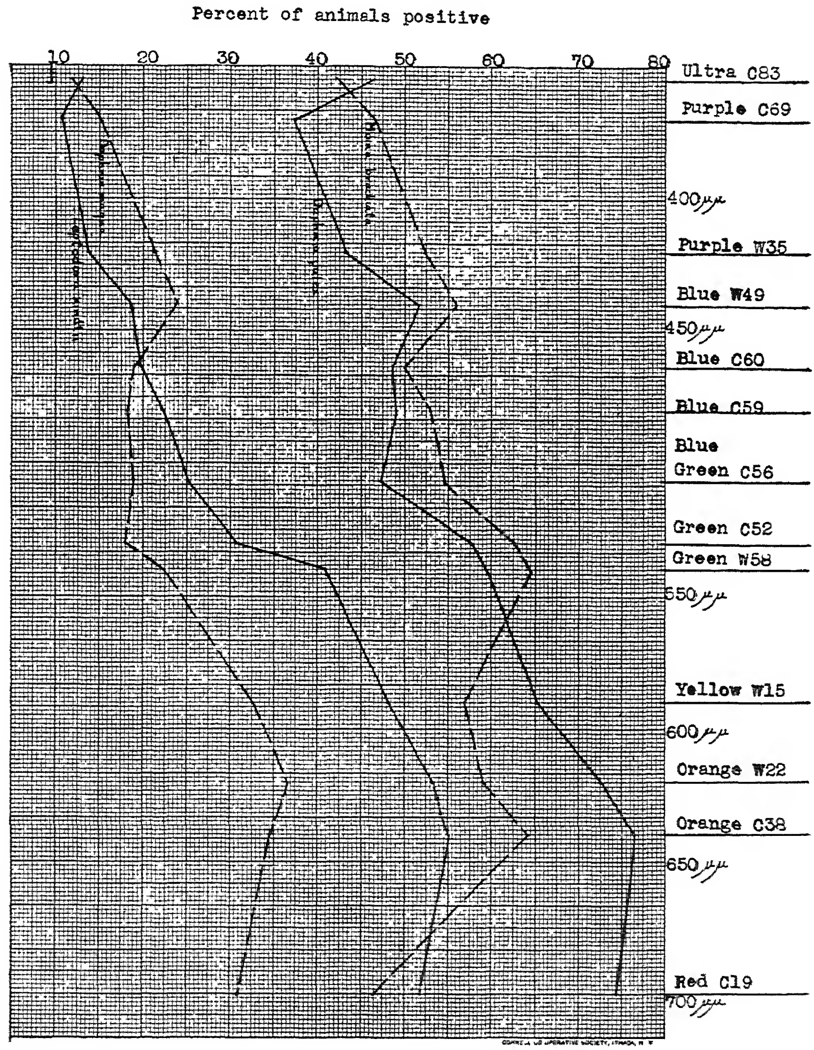

FIGURE 2. Curves showing the distribution of stimulating efficiency among colors equal in radiant energy content.

the curve for *Moina brachiata* appears markedly different from the others, it may be noted that it is quite similar to that for *Daphnia pulex* from the violet through the green; after that the effect is relatively much greater in the latter form.

There is, in the case of *Daphnia pulex* and *Leptodora kindtii*, a slight increase in effect toward the ultra-violet, while in the

TABLE III.

RESULTS OF EXPERIMENTS TO DETERMINE THE DISTRIBUTION OF STIMULATING EFFICIENCY AMONG DIFFERENT PORTIONS OF THE SPECTRUM OF EQUAL ENERGY CONTENT, FOR LEPTODORA KINDTII. THE FIGURES GIVEN IN EACH SET OF EXPERIMENTS ARE THE TOTAL NUMBERS OF ANIMALS POSITIVE TO EACH LIGHT IN THREE EXPOSURES.

Leptodora kindtii.

Average temp = 26.0° C.

Experiments	Animals per Experiment	Filters												
		C83	C69	W35	W49	C60	C59	C56	C52	W58	W15	W22	C38	C19
1	7 animals	5	2	3	5	6	6	5	8	9	6	10	11	8
2	8 "	4	5	4	6	6	4	5	7	9	13	13	14	17
3	10 "	11	10	9	11	11	8	11	11	12	15	12	10	13
4	8 "	4	1	3	6	4	6	8	11	14	14	18	17	16
5	10 "	3	2	2	2	3	4	6	10	16	16	20	24	22
6	8 "	1	0	2	5	5	6	3	9	11	12	13	15	15
7	9 "	4	4	7	6	13	13	12	11	15	14	17	16	18
8	10 "	2	2	6	3	5	5	6	9	13	21	16	19	17
9	10 "	4	4	2	3	3	3	4	3	6	9	11	10	7
10	10 "	2	4	4	4	6	6	7	11	9	11	12	14	14
11	10 "	3	3	4	5	6	6	6	9	12	14	18	15	8
Total	100 animals	43	37	46	56	59	67	75	92	126	145	160	165	155
Percent positive	....	14.3	12.3	15.3	18.7	19.7	22.3	25.0	30.7	42.0	48.3	53.3	55.0	51.7
Corrected for Red	....	13.1	10.8	13.7										

other two species, the efficiency is lowest in this region. It would have been desirable to test this region further, but this was not possible with the apparatus used, since light from a tungsten filament does not penetrate far into the ultra-violet.

It is also interesting to observe that the effect of red is rather high in three of the species; in fact it is almost as great as that of orange. For *Moina brachiata*, on the other hand, it is scarcely higher than the effect of violet.

IV. DISCUSSION AND CONCLUSIONS.

It is apparent that the results of these experiments differ from those of previous investigators, first, in that here the efficiency of the orange is greater than that of the green, or at least equal to it (*Moina brachiata*), and second, in that here the efficiency of red is relatively high, being, with the exception

TABLE IV.

Results of Experiments to Determine the Distribution of Stimulating Efficiency Among Different Portions of the Spectrum, of Equal Energy Content, for Daphnia magna. The Figures Given in Each Set of Experiments are the Total Numbers of Animals Positive to Each Light in Three Exposures.

Daphnia magna.

Average temp. = 21.0° C.

Experiments	Animals per Experiment	Filters												
		C83	C69	W35	W49	C60	C59	C56	C52	W58	W15	W22	C38	C19
1	6 animals	1	2	1	0	5	5	2	0	1	4	3	6	9
2	9 "	1	3	7	3	2	1	3	5	7	6	8	5	9
3	14 "	2	7	6	5	2	2	7	5	7	11	16	10	10
4	8 "	4	1	9	5	7	8	8	8	8	13	17	17	10
5.	7 "	7	6	7	6	5	5	6	5	6	8	8	11	9
6. . .	13 "	2	3	5	6	4	3	4	4	7	6	10	0	4
7.. ..	8 "	7	10	11	13	9	11	9	11	11	18	16	16	13
8.	10 "	3	5	7	12	6	3	2	1	3	8	13	9	9
9... .	12 "	3	3	7	8	6	5	7	4	5	6	5	7	12
10.......	13 "	9	10	9	13	11	12	9	11	12	18	14	14	6
Total. .	100 animals	39	50	69	71	57	55	57	54	67	98	110	104	93
Percent positive	....	13.0	16.7	23.0	23.7	19.0	18.3	19.0	18.0	22.3	32.7	36.7	34.7	31.0
Corrected for Red	.. ..	11.8	15.2	21.4										

of *Moina*, higher than that of the green. On the other hand, the results are similar to those obtained by v. Frisch and Kupelweiser, Becher, Koehler, and Peters, in that the animals are, as a rule, more positive to green, yellow, orange, and red, than to blue and violet. The only exception to this is *Daphnia magna*, which is about equally positive to green and blue.

The explanation of the discrepancies between these results and others may lie in one or more of the following factors; physiological condition; age; or the distribution of radiant energy in the spectrum.

The results in question were obtained with animals positive to light. The animals used in these experiments were either neutral (*Daphnia pulex*, *Moina brachiata*) or negative (*Daphnia magna*, *Leptodora kindtii*) to white light. Mast (1917) has shown that for certain organisms the distribution of stimulating effect is the same whether the organisms are positive or negative

TABLE V.

RESULTS OF EXPERIMENTS TO DETERMINE THE DISTRIBUTION OF STIMULATING EFFICIENCY AMONG DIFFERENT PORTIONS OF THE SPECTRUM, OF EQUAL ENERGY CONTENT, FOR DAPHNIA PULEX. THE FIGURES GIVEN IN EACH SET OF EXPERIMENTS ARE THE TOTAL NUMBERS OF ANIMALS POSITIVE TO EACH LIGHT IN THREE EXPOSURES.

Daphnia pulex.

Average temp. = 21.5° C.

Experiments	Animals per Experiment	Filters												
		C83	C69	W35	W49	C60	C59	C56	C52	W58	W15	W22	C38	C19
1 . .	10 animals	11	8	12	8	15	13	8	10	14	17	20	24	19
2 . . .	10 "	16	11	10	10	14	18	20	20	22	25	23	26	23
3 ..	10 "	12	9	8	12	11	10	7	15	22	20	23	22	23
4 .	10 "	15	11	12	17	15	13	16	16	23	19	21	25	25
5	10 "	18	17	17	24	21	20	22	24	24	19	24	23	27
6 . .	10 "	17	12	13	23	22	22	21	23	18	22	22	19	17
7 .. .	10 "	18	16	14	16	18	16	13	20	19	19	21	23	19
8. . . .	10 "	14	10	19	14	8	14	10	16	10	14	14	20	21
9	9 "	10	10	12	16	9	7	8	9	9	15	23	22	26
10......	6 "	5	7	11	7	6	7	10	12	9	16	16	14	12
Total....	95 animals	136	111	128	147	139	140	135	165	170	186	207	218	212
Percent positive	....	47.7	38.9	44.9	51.6	48.7	49.1	47.4	57.9	59.6	65 3	72.6	76.5	74 4
Corrected for Red	....	46.5	37.4	43.3										

to light. Although this has not been definitely shown for cladocera, it is rather to be expected, particularly if the distribution of stimulating effect depends on the presence of a fixed photosensitive substance. Consequently, the factor of physiological condition is, to a great extent, ruled out. A series of experiments on positively phototropic animals would be required, however, to settle this point definitely.

It is known that the phototropic reactions of cladocera change with age. Newly hatched animals are positive to light at all temperatures. As they grow older, however, they become

neutral or negative to light, and are positive only at low temperatures, the range depending on the particular species. This indicates primarily a change in physiological condition, but there is also a possibility that the nature of the photosensitive substance may change with age. In previous work, animals in various stages of development were used; here, the animals used were as nearly as possible of the same age. However, since animals of only one age were used, nothing definite can be said here concerning this factor.

It may be noted that in practically all previous investigations with Daphnia, in which the region of maximum efficiency was found to lie in the green or yellow, the monochromatic light was produced by a prismatic spectrum. The radiant energy of a prismatic spectrum increases from the blue to the red, slowly at first, then more rapidly (Mast, 1911, p. 306; 1917, p. 490). Thus, the radiant energy of the orange and red used in such experiments is much greater than that of the green and yellow. It is quite probable that the energy of the orange and red was, in cases where a prismatic spectrum was used, too great to elicit a positive response, especially since these animals are positive only within a limited range of intensities. With colors equal in energy, however, such a probability is eliminated; here the response to color is not hidden by an opposite response to intensity. This factor is the one which most readily explains the discrepancies between the results of these and previous investigations.

It may be concluded, accordingly, that the animals investigated are more strongly stimulated by some wave-lengths than by others, when the intensity of the various wave-lengths is equal. There is a region of maximum stimulating efficiency in the orange (620–640$\mu\mu$) for all the species investigated, and also an equal maximum in the green at about 540$\mu\mu$ for *Moina brachiata*. The stimulating effect falls off greatly toward the violet end, with a secondary maximum in the blue at about 440$\mu\mu$, and very little toward the red, except in the case of *Moina brachiata*. That these reactions are specific effects of the wave-lengths involved, and are not due merely to the amount of ultra-violet transmitted by each filter, as Becher maintains, is evident from the fact that not only is little ultraviolet transmitted by any but the purple filters, but whatever is transmitted is almost completely absorbed by the three layers of glass through which the light passes.

A comparison of the curves in Figure 2 warrants the further conclusion that the photosensitive substances in these four species, although fundamentally similar, are specific for each species. It is interesting to note that the curve for *Daphnia pulex* is more similar to that for *Leptodora kindtii* than it is to that for *Daphnia magna*. This indicates, as do the results of Mast (1917) and Hecht, (1928), that distribution of stimulating effect in the spectrum is not correlated with the degree in which the species are related.

V. SUMMARY.

1. Four species of cladocera (*Moina brachiata*, *Leptodora kindtii*, *Daphnia pulex*, and *Daphnia magna*) were exposed to a series of thirteen colored lights of equal intensity, and the percentages of the total number positive to each light determined.

2. Orange light (620–640$\mu\mu$) was found to have the maximum stimulating effect for all the species investigated. For *Moina brachiata*, the efficiency of green light (about 540$\mu\mu$) was approximately equal to that of orange. The discrepancy between these results and those of previous investigators, who maintained that green light had the maximum stimulating efficiency, is most probably due to the fact that colors equal in intensity were used in these experiments.

3. The stimulating efficiency falls off greatly toward the violet, with a secondary maximum in the blue at about 440$\mu\mu$, but very little toward the red, except in the case of *Moina brachiata*, where the effect of red is very low.

4. The curves for the distribution of stimulating efficiency, although essentially similar for these forms, are nevertheless different in certain details for each species. This indicates that the photosensitive substances are specific for each species, although fundamentally similar.

5. The similarity of the curves for two species is not correlated with the degree of relationship of the species since the curve for *Daphnia pulex* is more similar to that for *Leptodora kindtii* than it is to that for *Daphnia magna*.

BIBLIOGRAPHY.

Banta, A. M. "A Convenient Culture Medium for Daphnids." *Science, N. S.* Vol. 53, 1921, pp. 557–558.

Becher, S. "Neue Versuche zum Problem des Licht- und Farbensehens der Daphnien." *Verh. D. Zool. Ges.*, Bd. 26, 1921, s. 60–67.

Bert, P. "Sur la question de savoir si toux les animaux voient les memes rayons que nous." *Arch. de Physiol* T. 2, 1869, p. 547.
Borowski, V. "Uber das Verhalten von *Daphnia pulex* im verschiedenfarbigen Lichte." *Rusk, fisiologicesk. Zurnal.* Bd. 10, 1927, s. 11–31.
Ewald, W. F. "Versuche zur Analyse der Licht- und Farbenreaktion eines Wirbellosen (*D. pulex*)." *Zeitschr. fur Sinnes Physiol.* Bd. 48, 1914, s. 285–324.
Gardner, K. S., Tyndell, E. P. T., and McNichols, H. J. "The Ultra-violet and Visible Transmission of Various Colored Glasses." *Technologic Papers of the Bureau of Standards.* No. 148, 27 pp. Washington, 1920.
Hecht, Selig. "The Relation of Time, Intensity, and Wave-length in the Photosensory System of Pholas." *Journ. Gen. Physiol.*, Vol. 11, 1928, pp. 657–672.
Hess, C. "Neue Untersuchungen uber den Lichtsinn bei wirbellosen Tieren." *Arch. f. d. ges. Physiol.* Bd. 136, 1910, s. 282–367.
Klugh, A. Brooker. "The Ecology, Food-relations, and Culture of Fresh-water Entomostraca. *Transact. Roy. Canad. Inst.*, Vol. 16, 1927, pp 15–98.
Loeb, Jaques, and Maxwell, S. S. "Further Proof of the Identity of Heliotropism in Animals and Plants." *Univ. of Cal. Pub. Physiol.*, Vol. 3, 1910.
Lubbock, Sir J. "On the Sense of Color among Some of the Lower Animals. Part. I." *Journ. Linn. Soc. (Zool.)*, Vol. 16, 1881, pp. 121–127.
Mast, Samuel O. *Light and the Behavior of Organisms.* New York, John Wiley and Sons, 1911, 410 pp.
Mast, Samuel O. "The Relation between Spectral Color and Stimulation in the Lower Organisms." *Journ. Exp. Zool.*, Vol. 22, 1917, pp. 471–528.
Peters, Ernst. "Vergleichende Untersuchungen uber den Lichtsinn einheimischer Cladocerenarten." *Zool. Jahrb. allg. Zool.*, Bd. 43, 1926, s. 1–40.
Visscher, J. Paul, and Robert H. Luce. "Reactions of the Cyprid Larvae of Barnacles to Light with Special Reference to Spectral Colors." *Biol. Bull.*, Vol. 54, 1928, pp. 336–350.
v. Frisch, K., und H. Kupelweiser. Uber den Einfluss der Lichtfarbe auf die phototaktischen Reaktionen neiderer Krebse." *Biol. Cent.*, Bd. 33, 1913, s. 517–552.
Yerkes, R. M. "Reactions of Entomostraca to Stimulation by Light." *Amer. Journ. Physiol*, Vol. 3, 1899, pp. 157–182.

The Emergence of Life.

This book is an attempt to interpret Emergent Evolution on the basis of logical and mathematical theories which have been prominent in recent scientific discussion; and also to gather up suggestions from the classic philosophers. The basic interpretation is an idealistic theory of reality. The monadology of Leibniz is given a central position, though reinterpreted in a manner deemed necessary in the light of later thought. The emergence of life is regarded as following lines capable of accurate description in terms of mathematical logic. This calls for a reduction of structure to infinitesimals of the infinite order, and for a discussion of continuity and discontinuity in the light of mathematical-logical analysis of these concepts. Contributions are drawn from a wide range of scientific literature, physical and biological.

The result is an imposing array at certain points of mathematical and logical formulae, though their connection with the thesis presented is often so briefly given that the necessity of the connection and relevance to the theory are not clearly evident. The massing of differential equations, radicals, vector analyses, theory of groups, etc., seems more like a display of elaborate erudition than a convincing straightforward argument. To the general reader it looks quite forbidding. To the specialist it might easily look over-ambitious. An effective synthesis in a single volume might well dwell longer upon fundamental principles, rather than attempt to present too much detail, fundamental as this is ultimately.

—A. E. Avey.

The Emergence of life, by J. B. Burke. viii+396 pp. Oxford Univ. Press, 1931. $7.50.

DOMINANCE IN MAN, WITH ESPECIAL REFERENCE TO POLYDACTYLISM.*

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The determination of the dominance or recessiveness of any human character often presents difficulties. Most of the known human hereditary characters are recorded in small family histories, which by themselves are not sufficient to establish the dominance or recessiveness of the factor. Yet a factor which appears in each generation recorded, even though the family history be a small one, is usually stated to be a dominant. That this statement may not always be true can be readily shown by the histories of polydactylism given below.

As human heredity becomes better understood, the genetecist is more often called upon to give advice on the probability of certain characters appearing in the offspring of certain marriages. The requests are frequently from prospective mothers who wish to be reassured in the matter of certain undesired traits which have appeared in their ancestry. A thorough and accurate knowledge of the mode of the inheritance of any character is of course necessary before any statements as to the probability of its appearance in the offspring may be made, and the genetecist may well be chary of his advice.

That the difficulty of distinguishing a true dominant in man is not always understood may be realized from the following quotation from the recent syllabus of the introductory course in the biological sciences at a large and well known University. The statement is made, in connection with human heredity, that "It is not difficult to determine whether a trait is a dominant or recessive. If a trait appears in at least one of the parents, in at least one of the grandparents, and in at least one member of other ancestral generations, it must be dominant." The arbitrary application of such a principle may result in errors, especially in human pedigrees which are frequently short and which almost invariably start with a generation which actually shows the character.

*Studies in Human Inheritance VIII.

As a case in point may be cited some evidence on hand in our laboratory on the question of polydactylism. This character in white people is usually considered a dominant, because in general it appears to be handed down directly from parent to offspring. The available cases are comparatively few, however, and may not necessarily indicate dominance. The following new pedigree is typical of the kind usually recorded (Figure 1).

Here the character is handed down for three generations without a break. As is normally the case, however, nothing is known of the generation preceding the first in which the character is recorded. Such a pedigree would immediately be stamped as that of a dominant character. The pedigree to be given next will, however, show that this must not be taken for granted.

It is admitted that for the character to be recessive in the foregoing pedigree the mothers of the polydactylous children must in both cases have been heterozygous, and that the odds against this being so are enormous, but it must not be forgotten that these conditions are the very ones whose occasional occurrence bring the pedigree to our attention. When we read a story of a succession of amazing incidents happening to a man, we are prone to dismiss it with the observation that such a series of things would almost never happen, forgetting that the very fact that they did in this case happen may provide the only motive for the writing of the story. Thus the isolated occurrence of a character in a family passes by unrecorded time and again, while the repeated occurrence, from whatever cause, is noted and recorded. We have on record several cases of polydactylism in white people in which neither parent showed the character.

More critical data are provided in the case of polydactylism in negroes. The following pedigree was recently obtained in Columbus with the aid of Dr. J. H. Mitchell, (Figure 2).

This would appear to be the regulation dominant, and would be unhesitatingly called so if the principle cited at the beginning of this paper were followed. However, in a previous paper, one of us (L. H. S.) has shown that polydactylism in negroes is a recessive. It is not impossible that this is the same gene. Many parts of the original pedigree (Snyder, 1929) showed characteristics common to a dominant trait. Only upon careful examination of the more extensive record of the family history did it appear that the character must

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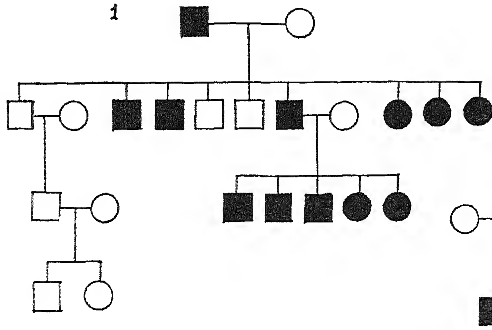

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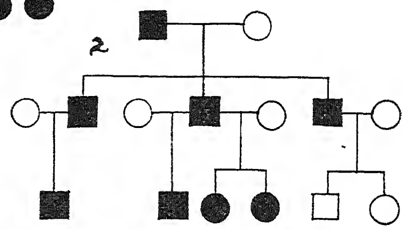

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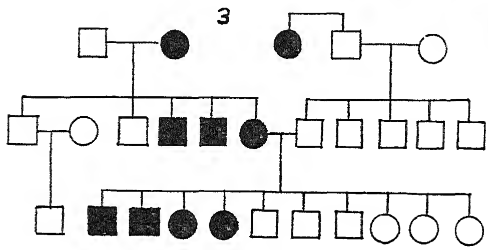

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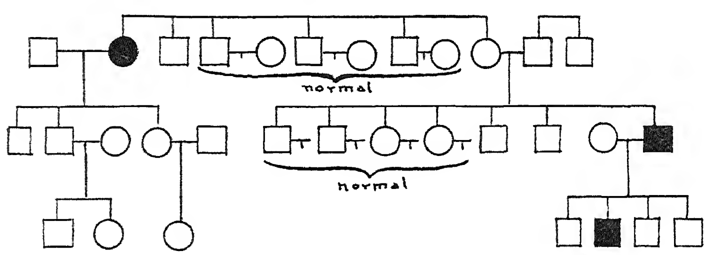

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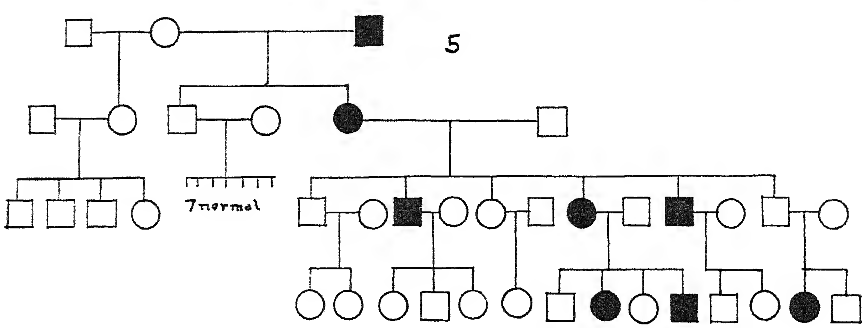

be recessive. Figure 3, another new pedigree of polydactylism in negroes, while again appearing at first glance dominant, shows more clearly that it may well be recessive, as the character appears in both lines of the family.

Finally figure 4, likewise a new pedigree in negroes, shows a clear case in which neither parent showed the character and yet transmitted it to a child. While this one case might only indicate the presence of an inhibitor or some other interaction of the factors concerned, reference to the original pedigree cited above will show this to be of frequent occurrence.

An interesting pedigree is offered in this connection in figure 5. This is a case of syndactyly in whites. The character appears dominant, but one case is shown where an abnormal child was born of normal parents. This family is especially interesting in that all syndactylous individuals had also six toes, while the normal individuals had the usual five toes. The number of fingers was in all cases normal. This may indicate a close linkage between syndactyly of the hands and polydactyly of the toes in this family.

In the case of a human character, then, which in a small pedigree or a series of small pedigrees appears in each generation, it is not adequate to arbitrarily designate it a dominant. The following possibilities must always be considered.

1. The factor may, of course, be a true dominant, a fact, however, the proof of which will require far more than the usual small pedigrees.

2. It may be a recessive, most frequently brought to our attention and recorded in pedigree form in those relatively rare cases in which an individual showing the character has married a heterozygote.

3. It may be brought about by any one of duplicate genes, certain of which may be dominant and others recessive.

4. There must always be considered the interaction and epistatic relationships of more than one pair of factors.

5. The character may occasionally appear due to a purely developmental abnormality simulating the hereditary condition, thus complicating the interpretation of family histories.

It must not be forgotten that even if the gene apparently is a dominant we usually have no way of knowing the composition of the homozygous mutant form. In many cases this may be lethal, so that the gene is really intermediate.

If one form of polydactylism is really dominant, as has been considered, the occurrence of a completely recessive form in other families throws an interesting side-light on Fischer's theory of the evolution of dominance. It becomes necessary to explain why one form of polydactylism has become recessive while another phenotypically indistinguishable form is dominant. This fact would favor Wright's suggestion that while the most frequently *occurring* mutations are recessive, those actually fixed in evolution may be either dominants or recessives, thus making it unnecessary to assume the evolution of dominance in new type genes.

BIBLIOGRAPHY.

Fisher, R. A. 1930. The Genetical Theory of Natural Selection. Clarendon Press, Oxford.

Snyder, L. H. 1929. A Recessive Factor for Polydactylism in Man. Jour. Hered. XX: 73–77.

Wright, S. 1929. Fisher's Theory of Dominance. Amer. Nat. LXIII: 274–279.

Heredity.

The second edition of a genetics text-book by a working genetecist makes its appearance five years after the publication of the original edition. The new book is an improvement over the old one, most especially in the addition of problems to be worked at the conclusion of the various chapters on types of inheritance. Much new material on human inheritance and its various practical applications is included, and certain worth-while additions are apparent in the fundamental chapters.

The author has proceeded on the commendable assumption that many students who would otherwise not obtain any instruction in biology can be led to a knowledge of the subject through an interest in human biology and especially human heredity. The book therefore assumes no previous biological instruction for its readers. Certain elementary facts concerning cells and development are therefore included where needed. The book appears to be exceptionally well suited to the elementary course in heredity, where an increasing knowledge of human inheritance makes it essential that more and more of this valuable material be used in developing an intelligent interest among students.—L. H. S.

Heredity, by A. F. Shull. Second edition, xv+345 pp. New York, McGraw-Hill Book Co., 1931. \$3.00.

RANGES OF pH TOLERANCE OF THE LEMNACEAE.*

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The hydrogen ion concentration is extremely important in many of the chemical reactions which take place within any plant structure and must be taken into consideration in any attempt to understand and explain those factors which may influence the growth, reproduction, abundance and distribution of the Lemnaceae or duckweed family.

Mineral salts in water in which aquatic plants are growing may: (a) furnish raw materials, (b) act as catalytic agents, (c) determine acidity and alkalinity of the medium and (d) provide a balanced solution. In addition, acids and alkalies may have a toxic effect upon living cells by changing their permeability.

The important effect of the extremes of pH concentration upon plant growth in general, being generally accepted, the present paper is a record of various experiments and field observations to determine to what extent the pH concentration ranges commonly found in the waters of the state of Ohio limit or promote the growth and distribution of the various species of Lemnaceae. The major portion of this work was done between October, 1928, and June, 1929, and this report is a revision of a paper prepared at that time.

In all, more than 660 hydrogen ion determinations were made of: (a) the waters in which 7 species of Lemnaceae were growing in 36 Ohio counties, (b) the organic media in which these same species were growing in greenhouse cultures and (c) various buffered inorganic salt solutions with pH values arranged in series.

METHOD OF MAKING DETERMINATIONS.

The colorometric, the quinhydrone and the hydrogen electrode methods of pH determination were compared and the quinhydrone method was found to be superior to the others in every way for the purposes of these experiments. All of the determinations given were made by that method. Samples of

*Papers from the Department of Botany, Ohio State University, No. 296.

water to be tested (free from duckweeds or other organic matter) were collected in 40 or 50 cc. stoppered, chemically clean glass bottles and carefully labeled with all necessary data. The actual determinations were made in the laboratory. Samples of greenhouse cultures were tested immediately after collection. Field samples were usually tested within a few hours after collection and at temperatures similar to those at the time of collection. Duplicate samples thus collected would check to within .01 pH or less and often gave identical readings to the third place. Samples redetermined three weeks after collection showed only a very slight variation from the original reading. Thus the method of determination used seemed to be an extremely accurate and practical one.

The pH concentrations of the stream waters of the state of Ohio, as determined from a limited number of samples, range from about pH 5.6 to pH 8.8, although many springs and stagnant bodies of water, especially swamps and bogs, may range down to pH 4. Most of the stream waters of the state are on the alkaline side of the neutral point, especially those of the western half of the state in the limestone areas.

Many of the streams of the acid-forming sandstone regions of the Alleghany Plateau are somewhat acid, especially in the sections covered by the Black Hand formation of the Sugar Grove region. More than 700 Ohio stream water pH determinations by the colorimetric method were made by E. L. Wickliffe, Chief of the Bureau of Scientific Research, Ohio Division of Conservation (unpublished). His results showed that the stream waters of the eastern half of the Lake Erie drainage average pH 7.5, the western half pH 8.0, the unglaciated Ohio drainage pH 7.27 and the glaciated Ohio drainage ph 7.9.

It is very important to remember that the pH concentration of any body of water is not a fixed value, but is highly variable. The extremes of pH values over a period of time are probably of more importance in effecting plant life than just the average pH values of the same period. pH values of water areas supporting duckweed populations are known to vary with (a) dissolved soil constituents, (b) temperature, (c) presence of buffers, (d) time of year or season, (e) amount of rainfall, (f) decay of organic matter and other factors.

Rather large variations in pH values result from temperature changes alone, especially in poorly buffered solutions. Low temperatures tend toward acidity, high temperatures

toward alkalinity. This is largely due to the greater amounts of carbon dioxide dissolved at the lower temperatures. Most of the very acid determinations made of bog waters are partly due to the lower temperatures of the water among bog plants. Samples of water collected only a few feet away from the edge of a sphagnum bog were often distinctly alkaline. A sample of distilled water at 23 degrees C. had a pH of 4.98, but when boiled for a few minutes to drive off the dissolved carbon dioxide, gave a pH value of 6.8. pH-temperature curves, made from readings taken by E. L. Wickliffe at Buckeye Lake over a period of several months, showed a rather distinct correlation between the two.

TABLE I.

Species	Number of Times Occurring in pH Values of									
	4.6 to 5.0	5.0 to 5.4	5.4 to 5.8	5.8 to 6.1	6.1 to 6.4	6.4 to 6.7	6.7 to 7.0	7.0 to 7.3	7.3 to 7.6	7.6 to 7.9
Spirodela polyrhiza	...	...	..	4	11	36	39	46	10	...
Lemna trisulca	....	...	8	5	28	35	7	2	..	...
Lemna minor	...	6	14	9	46	51	28	16	10	....
Lemna cyclostasa	....	..		2	6	4	1	..	....	....
Wolffia columbiana	....	..	..	5	14	23	21	12	10	....
Wolffia punctata	....	...	.	...	2	10	11	8	10	....
Wolffiella floridana	....	6	5	5	6	....	...	....	....	...

1. *pH Determinations of Water Media of Wild Plants.*

Table I summarizes the number of times each of the seven species studied occurred in water of the several pH ranges. The results include 212 determinations of water areas in 36 Ohio counties in which one or more species of duckweeds were found growing. Note that *Lemna cyclostasa* and *Wolffiella floridana* have a very restricted distribution in Ohio.

2. *pH Determinations of Greenhouse Cultures.*

A total of 228 pH determinations were made of the water media containing organic matter in which the seven species were growing under greenhouse conditions. Most of these determinations were made from November, 1928, to June, 1929. Cultures tested were of plants growing in tap water or pond water to which had been added a quantity of soil or crushed

stone of all types available, various fertilizers, manures, ground peat or other organic matter. The media produced varied from about pH 4 to pH 8 and made it possible to observe the plants in a wide range of growth conditions. Check cultures were made of each medium type prepared to aid in the interpretation of results. All pH determinations were checked by testing duplicate samples.

The size, general condition and rate of growth of the plants in each case, were carefully noted. Frequent renewals of the

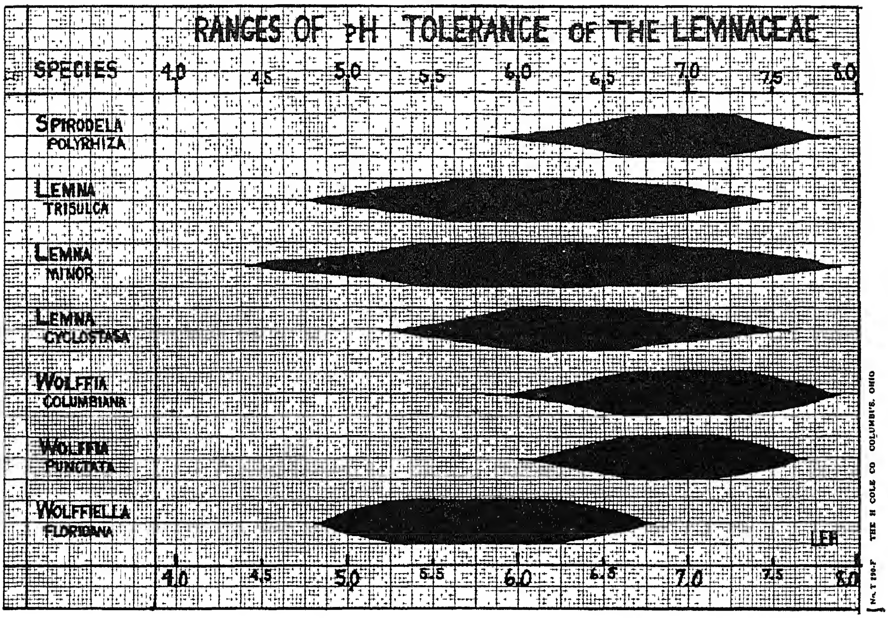
TABLE II.

Species	pH Values Accompanying		
	Good Growth	Fair Growth	Poor Growth
Spirodela polyrhiza	6.6 to 7.3	6.4 to 6.6 7.4 to 7.6	5.8 to 6.4 7.6 to 7.9
Lemna trisulca	5.6 to 6.5	5 2 to 5.6 6.5 to 7.2	4.6 to 5.2 7.2 to 7.5
Lemna minor...	5.4 to 6.8	5.0 to 5.4 6 8 to 7.4	4.5 to 5.0 7.4 to 7.8
Lemna cyclostasa	6.0 to 6.7	5.7 to 6.0 6.7 to 7.0	5.2 to 5.7 7.0 to 7.6
Wolffia columbiana.	6.5 to 7.4	6.3 to 6.5 7.4 to 7.7	5.8 to 6.3 7.7 to 7.9
Wolffia punctata........	6.5 to 7.3	6.3 to 6.5 7.3 to 7.6	6.0 to 6.3 7.6 to 7.7
Wolffiella floridana. .	5.2 to 6.2	5.0 to 5.2 6.2 to 6.5	4.8 to 5.0 6.5 to 6.8

medium to remove bacterial or algal growth, usually resulted in more rapid growth. There was considerable evidence to show that the pH value for best growth varies considerably with the composition of the medium. Plants in media containing an abundance of organic matter were tolerant of somewhat wider extremes of pH plants growing in media entirely or almost lacking in organic matter. As might be expected, plants in culture jars grew in a somewhat wider range of pH than plants of the same species occupy under natural conditions. A summary of growth results is shown in Table II.

3. *Growth of Plants of Seven Lemnaceae Species in Various Buffered Inorganic Salt Solutions with pH Values Arranged in Series.*

In these experiments a Clark (1925) series of buffer solutions was used. Cultures of 10 to 50 plants of each species were placed in 100 cc. wide-mouthed glass bottles with media of pH values as follows: 1.2, 2, 3, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 9 and 10. The medium used was made of equal volumes of



Clark's buffer solutions and Knop's solution. Later the experiment was repeated using Crone's and Shive's solutions. Also the experiment was repeated using McIlvaine's buffer solutions, but the results obtained were so nearly identical with those where Clark's solutions were used, that any of the variations in growth of the cultures appeared to be the actual effects of the pH values and were not seriously modified by any toxic or beneficial effects of the salts.

Where the plants remained alive, the old media were replaced with new solutions. In a few cases renewal was made every two or four days, but no differences in results were noted when compared with cultures which were changed at the usual

weekly periods. The pH of the media in each case was checked by the quinhydrone method at the beginning of the experiment and once (sometimes more often) each week thereafter. Where plants remained alive, the cultures were continued for a 12-week period.

All of the species in the pH 1.2 media died in less than an hour, the roots dying first, shriveling commencing at the tip and proceeding upward toward the point of attachment at the node. In the strong acid solutions, the *Wolffias* died first, then *Spirodela* and lastly the *Lemna* species.

In the literature, only two references were found concerning ranges of pH tolerance of any duckweed species. Clark (1926) grew *Spirodela polyrhiza* in solutions ranging from pH 4.4 to 4.8 and reported best growth from pH 4.6 to 4.8. This does not agree with my results or with those of Deuber (1926), who found that the same species made best growth from pH 6.2 to pH 6.8.

A summary of the results for each species is as follows:

1. *Spirodela polyrhiza.*—This species died in all of the media of pH 5 or less. Plants in pH 5.5 and pH 6 made poor growth, a few plants died and many resting plants were produced. Plants from pH 6 to pH 7.5 made vigorous growth and multiplied rapidly. At pH 8 very poor growth took place, but the plants remained alive 6 weeks and produced resting plants abundantly. More alkaline solutions killed the species.

2. *Lemna trisulca* died at pH 5 or below and at pH 8 or above, made poor growth at pH 5.5 and 7.5 and good growth from pH 6 to pH 7.

3. *Lemna minor* became pale in color and soon died at pH 4 or less and at pH 8 or more. Poor growth was made at pH 4.5 and 5.0. Good growth was made from pH 6 to pH 7.5.

4. *Lemna cyclostasa* died at pH 5 or below and at pH 8 or above, made poor growth at pH 5.5 and 7.5 and good growth from pH 6 to pH 7.

5. *Wolffia columbiana* died at pH 5.5 or below, made poor growth at pH 6, vigorous growth at pH 6.5 to pH 8, poor growth again at pH 8.5 and eventually died, but lived a number of days even at pH 9 and 10.

6. *Wolffia punctata* gave results almost identical with those of *W. columbiana* except that the species was slightly less tolerant of the pH extremes.

7. *Wolffiella floridana* grew only from pH 5 to pH 6.5.

SUMMARY AND CONCLUSIONS.

1. The pH concentration, though not always a limiting factor in our waters, is often an important one in affecting growth and distribution.

2. Some factor other than pH must be used to explain the total absence of duckweeds in a number of important bodies of water in the state. Examples: Bonnett Lake, Holmes Co., pH 6.34; West Swamp, Westerville, Franklin Co., pH 6.96; Chippewa Lake, Medina Co., pH 6.31; and Lake Brady, Crystal Lake, Muzzey Lake and Lake Pippen, all in Portage Co., with waters of pH 7.07, 5.77, 6.55 and 6.37, respectively.

3. *Spirodela polyrhiza*, almost without exception, is deeply pigmented wherever found in alkaline waters. *Lemna minor* frequently produced some red pigment in waters of pH 7 to 7.9.

4. *Spirodela polyrhiza* was found in waters ranging from pH 5.9 to 7.9 and was abundant from pH 6.3 to 7.5.

5. *Lemna trisulca* grew in waters ranging from pH 4.9 to 7.3 and abundantly from pH 5.1 to 6.7. This species, however, showed a marked preference for the cool acid waters of bog types.

6. *Lemna minor* showed a marked tolerance for pH variations, being found from pH 4.4 to 7.9 and abundantly from 5.1 to 6.7, a tolerance range including the pH ranges of tolerance of all of the other Ohio species.

7. *Wolffia columbiana*. Range of pH 5.9 to 7.8. Best growth and most abundant from pH 6.4 to 7.4.

8. *Wolffia punctata*. Range of pH 6.0 to 7.7. Best growth and most abundant from pH 6.4 to 7.4.

9. *Wolffiella floridana* tolerated pH ranges of 4.8 to 6.8. This species grows best among the abundant organic matter of bogs or boggy-swamp types.

10. The following graph shows the ranges of pH tolerance of each species as indicated by the results of the three sets of experiments and pH determinations. The width of the bands following each species indicate the frequency of occurrence and the limits of good growth of each species for each pH value.

LITERATURE CITED

Bottomly, W. B. 1914. Some accessory factors in plant growth and nutrition. Proc. Roy. Soc. Bot., B. 88: 237–247.

1917. The growth of *Lemna minor* in culture solutions. Proc. Roy. Soc. Bot. 89: 481–507.

1920. The growth of *Lemna* plants in mineral solutions and their natural medium. Ann. of Bot. 34: 345–352.

Clark, N. A. 1926. Plant growth promoting substances and pH and the reproduction of *Lemna*. Plant Physiol. I: 273–279.
Clark, W. M. 1925. The determination of hydrogen ions Williams and Wilkins Co., Baltimore, Md., pp. 1–475.
Deuber, C. G. 1926 Potassium Ferocyanide and Ferric Ferocyanide as Sources of Iron for Plants. Soil Sci. 21: 23–26
Hicks, Lawrence E. 1930. Physiological experiments with the Lemnaceae Proc. Ohio Acad. Sci. 8: 393–394.
Hicks, Lawrence E. 1932. Flower Production in the Lemnaceae. Ohio Jour. Sci 32: 115–132, 2 pl.
Persall, W. H. 1925. Hydrogen ion concentration and growth. Sci. Prog 20: 58–67.
Saeger, A. V. 1925. The growth of *Lemna minor* in mineral nutrient solutions. Jour. Gen. Physiol. 7: 517–526.
Shive, J. W. 1915. A three salt nutrient solution for plants. Am. Jour. Bot. 2: 157–160
Tottingham, W. E. 1914. A quantitative chemical and physical study of nutrient solutions. Physiol. Res. I: 133–345.

Progress in Microbiology.

This is the third book to appear in the "Century of Progress" series published in connection with the Century of Progress Exposition. It is an exceedingly interesting account of the part microbes have played and are playing in man's varied activities. The first thought in the minds of many on hearing the word microbe is "disease." This story of microbes, while taking full account of the important part played by microscopic forms in disease, draws interest as well to the useful and essential activities of such forms in agriculture, industry, sewage disposal and other of man's fundamental problems. The development of the story of microbes and man is so clearly and instructively drawn that the book should appeal to a wide circle of readers among those interested in keeping informed on modern progress in the sciences.—L. H. S.

Man and Microbes, by STANHOPE BAYNE-JONES. x+128 pp. Baltimore, The Williams and Wilkins Co., 1932. $1.00.

The Story of Living Things.

A series of lectures given at the University of California has grown into this very excellent account of the evolution of the biological sciences. The author has the rather rare faculty of writing an historical account in such a way that one reads it with a sense of pleasure rather than as a duty. The book is a rather complete account of the development of biological knowledge, theory and philosophy. The men concerned with such development are made vital personalities, and their beliefs and influence are set in relief against the unfolding background of increasing knowledge.

The author, while trying to be as fair to the mechanists as possible, is at heart a vitalist. The book begins and ends on the same note—a belief that life is unique and not entirely mechanistic.

No student of biology, beginner or experienced investigator, should fail to read this thoroughly readable history of his science.—S.

The Story of Living Things, by CHARLES SINGER. xxxv+572 pp. New York, Harper and Bros., 1931. $5.00.

THE REBUILDING OF MOUNDS OF THE ANT, POGONOMYRMEX OCCIDENTALIS, CRESS.

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Ohio State University.

The mound of *Pogonomyrmex occidentalis* passes through three stages of development. The first is represented by a small crescentic pile of earth arranged by the queen at the origin of the formicary; the second, the crater type of mound, usually present during the second year; and the third, the dome- or cone-shaped mound of the fully developed formicary. The time required for the complete development of the mound apparently varies with the number of workers comprising the colony and also, to a great extent, with the environmental conditions present throughout the period of mound construction. In the majority of colonies three years are required for the natural development of the mounds, while for others shorter periods are evident. The writer is inclined to believe that mounds of *occidentalis* are fully developed only when they possess rather sharp mound apexes. If this is true some never reach their possible limits.

Strong northwesterly winds, prevalent over the arid sections of Idaho, contribute their share to incomplete mound development, and, in some cases, to complete mound destruction. This is especially true in unprotected areas where the soil is fine and loose. Generally, only a short time is required for the workers to rebuild mounds partially levelled by the wind. A comparison was made of the time required for the rebuilding of wind-leveled mounds with that for the rebuilding of those mounds which were artificially-leveled by hand, the results of which appear in Tables I and II. These data were taken in the vicinity of Twin Falls, Idaho, during the summer of 1931. The number and position of the nest entrances remained fairly constant, and in only one case, of the mounds under observation, was an additional entrance produced during the rebuilding process. The tables illustrate the fact that, in most cases, the mounds were rebuilt with slightly greater dimensions than the

original structures possessed. The rate of rebuilding is apparently proportional to the numerical strength of the colony, as is also the case during the normal building process. Therefore, mounds leveled or partially leveled in the above fashions are built with greater rapidity than are the original structures.

TABLE I.

The Rebuilding of Artificially-leveled Mounds of *Pogonomyrmex occidentalis* Cr.

Mound Number	Height in Inches Before Leveling	Height in Inches After Rebuilding	Time Required, in Days, for Rebuilding
1	15 2	16.1	20
2	15 6	15.8	17
3	14 2	14.7	23
4	16 1	16.3	21
5	15.8	15.7	17
6	14 3	14.7	20
7	15.4	16.0	28
8	16 0	16.1	21
9	22.4	.21 8	34
10	15.4	15.9	23

TABLE II.

The Rebuilding of Wind-swept Mounds of *Pogonomyrmex occidentalis* Cr.

Mound Number	Height, in Inches, of Wind-swept Mounds	Height, in Inches, After Rebuilding	Time Required, in Days, for Rebuilding
1	14 1	15 0	12
2	13 6	14 4	12
3	13 8	14 9	14
4	13 2	14 2	18
5	14 2	14 8	17
6	18 5	19.1	12
7	13.9	22 4	15
8	13 4	15 8	17
9	13.7	15.1	19
10	14 3	16.3	21

NESTS OF THE ANT, FORMICA SUBPOLITA MAYR, IN THE WESTERN UNITED STATES.

ARTHUR C. COLE, JR.,
Ohio State University.

Formica subpolita has a wide distributional range. The writer has collected it from Minnesota, South Dakota, Wyoming, Idaho, Utah, Nevada, Arizona, Oregon, and California, while Wheeler[1] has further listed it from Colorado and Washington. The nests are found in a variety of habitats, ranging from the hot, dry desert sands to the cooler and more moist plains. They are especially common in southern Idaho and northern Nevada. The altitude range of the insect seems to lie between 2,000 and 6,000 feet. Numerous specimens have been taken by the writer at Cloud Cap Inn, on Mount Hood, Oregon, at an altitude of approximately 6,000 feet, on the rocky, almost vegetationless slopes. There the colonies consisted of only a few individuals, while under more favorable conditions they are generally a great deal more populous.

The nests of *subpolita* are commonly under rocks and only the superficial galleries and chambers are exposed to view when the rocks are removed. Nests have been found, however, in different situations. The writer discovered one nest under dry cow dung, while Wheeler[2] states that *subpolita* occasionally constructs large crater-mounds.

The nest openings are usually regularly circular in outline but vary in size and numbers, as do the galleries and chambers. Generally speaking, there are from one to four openings to each nest. The writer has never observed a nest with more than four openings. Perhaps the average is about three. I have repeatedly noticed that nests in the desert and semi-desert regions contain a greater number of openings than those in less arid environments. This may be due in part to the number of individuals composing the colonies or to the temperature and moisture conditions of the habitat, or both.

The nest chambers were usually found about 18 inches below the surface of the ground and apparently varied in

[1]Wheeler, W. M., *Ants, their structure, development and behavior*, Columbia Univ. Press, New York, 1926.

[2]Ibid., p. 201.

number with the numerical strength of the colony. They harbored the brood, all stages being mixed regardless of age. In some of the chambers various seeds were stored with the brood. Even the superficial chambers at the surface occasionally contained mixed seeds. It would seem from this that *subpolita* might possess granivorous as well as carnivorous and secretivorous[3] habits. However, no ants were found carrying seeds into the nests, a process which must be observed before a granivorous habit can be correctly assigned to the species. One or more of the superficial chambers usually contained parts of dead insects which had apparently been rejected by the ants. The superficial chambers sometimes contained brood of various ages, and even winged adults in some cases. In the vicinity of Twin Falls, Idaho, "desert pearls," or "earth pearls," an undertemined species of coccid, were in the surface chambers.[4] This is apparently the first record of their appearance in ant nests of the United States and certainly in those of *F. subpolita*.

The queens, which, in the vicinity of Twin Falls, migrate during early July, dig small surface chambers under rocks and there deposit eggs. Only when workers have emerged is the size of the formicary increased. The nest, has, at first, only one entrance but later may contain three or four, as mentioned above. Thus the incipient nest is nothing more than a small chamber under a rock. This chamber apparently remains, and in its original condition, even after the formicary is fully developed.

Cockerell[5] reports that *Elasmosoma vigilans* is a parasite of *Formica subpolita*, in Colorado, and *F. subpolita* has been taken as a slave of *F. pergandei*, *subintegra*, and *puberula*.[6]

The assistance given to this problem by Miss Marjorie Romaine, Bureau of Plant Industry, United States Department of Agriculture, is greatly appreciated by the writer.

[3]I suggest the term "secretivorous" for those ants which feed upon the secretions of aphids, coccids, membracids, etc.

[4]These have been reported from ant nests in St. Vincent and South Africa by Guilding, B. A., "An account of Margarodes, a new genus of insects found in the neighborhood of ants'-nests," *Trans. Linn. Soc. London*, XVI, (1829), 115–119; and by Trimen, R., "Notes on insects apparently of the genus Margarodes, Landsd.-Guild., stated to occur abundantly in the nests of white ants and also of true ants in certain western districts of the Cape Colony," *Trans. Ent. Soc. London*, (1886), 471.

[5]Cockerell, T. D. A., "A new Braconid of the genus Elasmosoma," *Proc. Ent. Soc. Wash.*, X, (1908), 168–169.

[6]Wheeler, W. M., op cit., p. 460.

A COMPARISON OF THE ALIMENTARY CANALS OF THE ACTIVE AND HIBERNATING ADULTS OF THE MEXICAN BEAN BEETLE, EPILACHNA CORRUPTA MULS.

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INTRODUCTION.

The Mexican Bean Beetle (*Epilachna corrupta* Muls.) is a serious pest of beans, and unlike other members of the Coccinellidae is entirely phytophagous in habit. The beetle hibernates as an adult under leaves, pine-needles, grass, and the like.

The following results represent an attempt to describe the differences in histological structure that occur during the hibernating stage of the beetle.

THE GROSS ANATOMY.

Active adult.—The alimentary canal of the Mexican Bean Beetle is a much convoluted tube running from mouth to anus, and is approximately three times the length of the body. It is divided into three main divisions, the fore-intestine (stomodaeum), the mid-intestine (mesenteron or ventriculus), and the hind-intestine (proctodaeum). (Fig. 1).

The fore-intestine arises as an invagination of the ectoderm, the germ layer from which the hypodermis of the body wall is derived. It consists of pharynx, oesophagus, and crop, no gizzard being present. It is about 2 mm. in length.

The pharynx is a short tube, scarcely 0.15 mm. in diameter, and connects the mouth with the oesophagus.

The oesophagus extends from the pharynx to the crop, the posterior limit reaching the region of the mid-portion of the prothorax. It is but little larger in diameter than the pharynx, measuring on the average about 0.25 mm. The only essential difference between the pharynx and the oesophagus is size.

The crop appears as a small bulb which is slightly larger in diameter than the oesophagus. It is marked at the anterior end by the oesophagus and at the posterior end by the oesophageal valve.

[1]The author wishes to express his appreciation to Dr. C. H. Kennedy of the Entomology Department of the Ohio State University, under whose direction this work was carried on. He also wishes to acknowledge the helpful suggestions and criticisms of Mr. B. J. Landis of the Bureau of Entomology.

The material for this study was kindly furnished by Dr. N. F. Howard of the Bureau of Entomology.

The oesophageal valve denotes the division between the fore-intestine and the mid-intestine and is indicated by a constriction of the stomodaeum. The valve lies in the region of the posterior sector of the prothorax.

The mid-intestine arises embryologically as an endodermal sac from the proliferation of rings of endodermal cells, one around the posterior end of the fore-intestine, the other around the anterior end of the hind-intestine. The mid-intestine is the longest of the three main divisions of the tract, measuring 9–10 mm. It is divided into two distinct portions, the anterior and the posterior portions of the ventriculus.

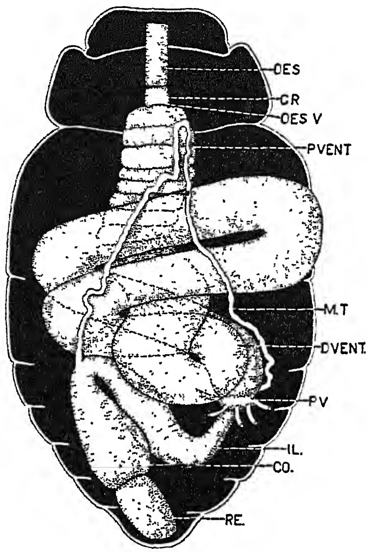

FIG I

Gross dissection of alimentary canal of the active adult of the Mexican Bean Beetle. OES., oesophagus; CR, crop; OES. V., oesophageal valve; P. VENT., anterior portion of ventriculus; M. T., Malpighian tubule; D. VENT., posterior portion of ventriculus; P. V., pyloric valve; IL., ileum; CO., colon; RE., rectum.

The anterior portion of the ventriculus measures 0.75–1.0 mm. in diameter and is characterized by a series of eight or more pseudo-segments. This area comprises about one-third of the mid-intestine.

The posterior portion of the ventriculus is marked by the gradual diminishing of these emarginations and caudad by the pyloric valve. It is in this section of the alimentary canal that the greatest convolution and doubling of the tract occurs. This part of the ventriculus is perhaps slightly smaller than the anterior portion and gradually diminishes in size to the valve.

The hind-intestine arises from the same germ layer as does the fore-intestine, and in the adult beetle is approximately 6 mm. in length. It is divided into four regions, the pyloric valve, the ileum, the colon, and the rectum.

The pyloric valve is distinguished in gross dissection as the point of origin of the six Malpighian tubules. These arise as spokes of a wheel, take a winding course up the mid-intestine as far as the crop, retrace themselves, and apparently return into the tract at the anterior part of the colon.

The ileum is bounded by the pyloric valve at the front and by the colon at the rear. It has a length of 2.5 mm. and a diameter scarcely over 0.25 mm.

The colon links the ileum and the rectum. Its anterior boundary may be recognized by the re-entrance of the Malpighian vessels into the tract. It is 2 mm. in length and slightly pear-shaped, its greatest diameter at the caudal portion being 0.75 mm. The six Malpighian tubules that enter may be seen to follow a winding course under the

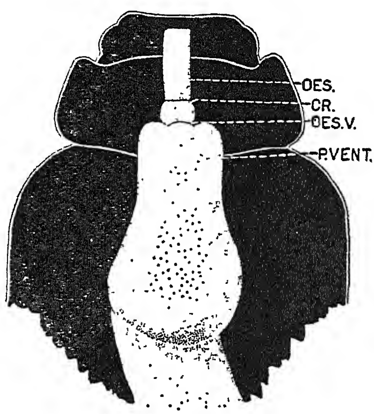

FIG 2.

Gross dissection of the anterior portion of the ventriculus of the hibernating Mexican Bean Beetle. OES., oesophagus; CR., crop; OES. V., oesophageal valve; P. VENT., anterior portion of ventriculus.

peritoneal membrane down the entire length of the colon, the greatest meandering taking place near the rectum where they terminate.

The rectum is about half the width of the widest part of the colon, slightly barrel-shaped and only 1.0 mm long.

Hibernating adult.—The fore-intestine is not different in gross structure from that of the active adult.

The anterior portion of the ventriculus, however, loses its segmented appearance, becoming greatly bulged and apparently very thin walled. This bulging effect varies in different specimens, the measurements ranging from 1.5–2.5 mm. at the widest point. This effect seems to be restricted to the first region of the mid-intestine in specimens taken from hibernation quarters in January, 1930, at Columbus, Ohio. Whether this would hold true in specimens taken later in the season of hibernation is not known. (Fig. 2).

Beginning at the posterior portion of the ventriculus, the size of the tube gradually decreases and becomes thread-like, continuing thus in

miniature throughout its entire length, the different parts still holding their gross morphological structure.

This thread-like appearance is even found in the Malpighian vessels, which become very minute.

HISTOLOGY OF THE ALIMENTARY CANAL.

FORE-INTESTINE.

Active adult.—Throughout the fore-intestine there is a similarity of structures in its various parts. From the inside outward, the following structures appear:

1. Intima, or Cuticula of chitin, which is directly continuous with the cuticula of the body wall.
2. Epithelium of hypodermal cells.
3. Basement membrane.
4. Longitudinal muscles.
5. Circular muscles.

The intima is secreted by the hypodermal cells and is rather a thin, non-cellular, almost transparent layer which lines the whole fore-intestine. The layer of chitin in the pharynx, however, is thicker than in the other parts of the fore-intestine. (Plate I, Fig. 1).

Potts (1927) states that the intima of the oesophagus possesses teeth, but in this study, after examining many sections of this region, no teeth or spines were found. (Plate I, Fig. 7). In the crop, however, the intima is lined with rather long, stout spines, pointing, for the most part, caudad. These, in the absence of the gizzard, are probably used to grind up the food and help it on its way into the mesenteron.

The epithelium of the fore-intestine is continuous with the hypodermis. The cells are very small, the cell walls not always being clearly defined.

The basement membrane is not easily distinguished.

Outside the basement membrane are isolated bundles of longitudinal fibers.

Surrounding the longitudinal muscle fibers is a more conspicuous layer of circular muscle fibers.

The crop appears as a bulging of the fore-intestine into a pouch (Plate I, Figs. 1, 3). The wall makes a fold, forming a double pocket, the entire lining of the crop being stoutly spined. The epithelial layer is not as distinct as in the other parts of the stomodaeum, but the part is more heavily muscled. Many strands of longitudinal muscles are attached to the pockets and terminate in the lips of these oesophageal valves. These, with the aid of the circular muscles, motivate the expansion and contraction of the crop, driving the food materials through the valve and into the stomach.

The oesophageal valve is formed by the protruding of the fore-intestine into the lumen of the mid-intestine, the projection folding back on itself in such a way as to form lip-like structures. (Plate I, Fig. 1). This reflected surface joins the wall of the mesenteron. It is at this point that the chitin of the stomodaeum disappears. The epithelium layer of the fore-intestine once more comes into prominence

at the cephalad portion of the valve, the cells becoming larger as the tip of the valve is reached. At the point most caudad in the lips of the valve, the longitudinal muscles are anchored, connecting this portion with the out-pocketings of the crop. Immediately outside this layer are numerous bundles of circular muscle fibers. This region is very heavily muscled, probably for the purpose of grinding and forcing the food into the stomach and preventing, by the contraction of the circular muscles in the valve, the regurgitation of predigested food.

At this junction of the fore- and mid-intestine the longitudinal muscles cross over the circular muscles.

Hibernating adult.—There are no differences in the histological structure of the fore-intestine in the active adult and in the hibernating form.

The Mid-Intestine.

THE ANTERIOR PORTION OF THE VENTRICULUS.

Active adult.—The anterior portion of the ventriculus consists of about one-third of the total mid-intestine, and is characterized by a series of folds, eight or ten in number. In gross dissection, they appear as segments of the intestine, but in section they show up as annular invaginations. (Plate II, Fig. 3).

The structure of the mid-intestine is markedly different than that of the fore-intestine. There is no chitinous intima, that structure being lost at the oesophageal valve. The layers of the mesenteron from the inside outward are as follows:

1. Intima, not chitinous.
2. Epithelium.
3. Basement membrane.
4. Circular muscles.
5. Longitudinal muscles.
6. Peritoneal membrane.

It will be noted that the circular muscle and the longitudinal muscle layers have changed position, the longitudinal muscle being on the outside.

The food of the stomach is always enclosed in a thin, elastic membrane known as the peritrophic membrane, which holds the food together in a compact cylindrical mass. This membrane is probably not chitinous but a secretion formed at the surface of the epithelial cells.

The epithelium layer is composed of elongate, columnar cells, closely following the folding of the tract and giving it its annular segmented appearance. (Plate II, Fig. 3). The inner surface of these cells possess a striated border.

Folsom and Welles (1906) in their paper on the mid-intestine of Collembola say in part, "The intima, or lining membrane, is a secretion of the stomach. It is striated transversely. . . . . They are due in all probability to minute pore-canals, through which fluid may be either secreted or absorbed. Frenzel, Oudemans, Somner, Gehuchten and others have described and figured the intima as a layer of fine filaments, to which they gave the name of 'Harchensaum.' In *Tomocerus*, however, the intima presents no such appearance, but it is clearly a

membrane." So is it with the Bean Beetle, a membrane lining the epithelial cells that projects into the lumen of the gut. This layer is not always the same thickness throughout the mid-intestine, but becomes thinner in some parts.

Between the basement membrane and these epithelium cells are groups of replacement cells or nidi. In a cross section, as many as thirty of these replacement cell nests may be present. They are located on the basement membrane and extend up towards the lumen of the stomach, being surrounded by the epithelial cells. (Plate II, Fig. 1). These nidi do not fall beneath the muscle layers as is the case in many Coleoptera. They are specialized for the formation of new cells to take the place of those that are destroyed by secretion.

Surrounding the nidi, underneath the basement membrane is situated a rather prominent layer of circular muscles.

The longitudinal muscles lie in isolated strands outside the circular muscle layer.

Hibernating adult.—In the hibernating beetle an altogether different condition exists in the fore part of the mid-intestine. There appears a curious splitting of epithelial tissue that closely resembles the one found by Folsom and Welles (1906) in Collembola during the moulting periods.

In the extreme anterior portion of this region, the only evidence of this condition is the distended and structureless remains of the original epithelial layer. It is this part of the intestine that gives the swollen, thin-walled appearance in the gross anatomy. (Plate I, Figs. 5, 8).

In order to understand this condition, it is necessary to describe a section taken farther down the canal showing all the structures involved in this degeneration of epithelial tissue.

The food material in this part is surrounded with a peritrophic membrane, the food in this case being partly digested cells, distinguishable by the nuclei that are apparently the last part of the cell contents to become disintegrated. (Plate I, Fig. 2).

The fact that they are cells that are undergoing degeneration and not food particles from other sources is borne out by the absence of a striated border on the cells that now are around the lumen of the gut.

The cell walls of this inner layer of epithelium are not clearly defined, but the arrangement of the nuclei and the remains of cell walls clearly denote that this layer has been cut off from the layer just beneath it.

This inner layer of epithelium also has a thin peritrophic membrane surrounding it.

The remaining structure of the original or outer epithelium layer is very difficult to distinguish. It is a very thin layer, almost structureless, containing a few scattered nuclei. The cell walls are scarcely visible, the whole structure resembling a ring of almost homogenous cytoplasm, dotted here and there with a nucleus.

The remains of nidi may be seen in a few places. They have become very reduced in size and discernible only at scattered points in the sections.

Around the very thin basement membrane is a fine band of circular muscles, surrounded by scattered strands of longitudinal muscles.

It is this thin outside epithelial layer that remains in the extreme cephalad portion of the region. This part of the stomach contains no food materials of any sort, appearing in cross section as a thin, inflated ring. The absence of food in this region would suggest that after the disintegration of the cells at this point, they move down the tract, either becoming digested or stored, to be excreted when the beetle comes out of dormancy.

THE POSTERIOR PORTION OF THE VENTRICULUS

Active adult.—The posterior portion of the ventriculus is characterized by the absence of the annular pseudosegments.

The layers of this portion of the ventriculus are similar to those of the anterior portion, the difference being in the shape of the epithelial cells.

The epithelial cells in this area are simple columnar and are much shorter than those of the preceding region.

At the caudal end of the posterior portion the epithelial cells again lengthen out until at the pyloric valve the cells almost entirely fill the lumen of the gut. (Plate I, Fig. 6).

In this region of the mid-gut it is possible to study the replacement of cells by nidi. (Plate II, Fig. 2). It appears as if each nidus replaced cells from a certain restricted area, making a line of demarcation between the replaced cells of one nidus from another. The nidi are small, rounded structures containing many nuclei, those on the border of the nidi towards the epithelial layer being somewhat flattened. The newly formed cells from these replacement nidi are small, flask-shaped structures. These cells are laid down alternately, each nucleus coming to the surface of the nidus and then becoming sloughed off, the axis being at the outer borders of the nidus. These new cells continually grow in size until they have reached the lumen of the gut. These cells contain many large vacuoles which, combined with the great rapidity in the replacement of cells, tend to show that a great deal of the secretion of the mid-intestine takes place in the region just anterior to the pyloric valve.

Hibernating adult.—This region of the mid-intestine of the hibernating adult also supports the marked change in structure from that of the active insect. It is very similar to that of the preceding hibernating region except that the outer epithelial layer is much thicker, and the cell walls are much more visible. (Plate I, Fig. 4).

Folsom and Welles (1906) consider this degeneration of epithelium tissue as an excretory function in Collembola. In the Mexican Bean Beetle that can hardly be the case, but it is possible that it is a mechanism to keep the animal nourished during its hibernation period by consuming its own cell body!

SECRETION.

Active adult.—In the insect world there are two distinct types of secretion, merocrine and holocrine. Merocrine is defined in *Stedman's Medical Dictionary* as, "Noting a gland, the product of which is secreted by the cells, the latter not being destroyed, such as a mucus gland."

This type of secretion is found in some Dipterous larvae where the digestive fluids are diffused through the cell wall, the cell itself not being destroyed. Holocrine is defined in *Stedman's Medical Dictionary* as, "Noting a gland (1) whose function is purely secretory, or (2) the secretion of which consists of altered cells of the gland, such as a sebaceous gland." *Webster* defines the term as, "Wholly used for secretion, applied to those cells whose entire substance is given up as a secretory product." In insects, the latter type seems to be the most common form of secretion in the mid-intestine.

Secretion in the Mexican Bean Beetle is a modified holocrine type, apparently taking place anywhere in the mesenteron, but more especially in the posterior portion of the ventriculus, and gaining its maximum just anterior to the pyloric valve. The cells at the time of secretion do not actually burst and let the contents flow out into the gut, but the ends of the secreting cells become constricted and form balls of digestive fluid, which finally pinch off and allow the globules to become free in the lumen of the stomach. During the process of secretion, the intima remains around the globule until it has been separated from the cell proper. (Plate II, Figs. 4, 7). The intima around the globule is greatly thinned, evidently due to the stretching of the intima. At the time of separation, the intima breaks, leaving but part of a border around the globule. The intima at the breaking points, however, apparently reunites and leaves the secreting cell intact except for its loss of cell contents through the process of secretion. In no case was the nucleus of the secreting cell found in the globule that was secreted.

These globules become less definite in outline as they reach the food body in the center of the lumen.

The secreting cells of the epithelium in the mid-gut are long and turgid with the secreting substance, becoming convex at their free surface. In the secreting cells large vacuoles occur, supposedly containing the digestive materials.

Replacement cells or nidi are very prevalent in the mid-intestine, suggesting that the secretory cells become functional, secrete, discharge, digest, and die, giving their places to new cells which arise from the nidi.

Hibernating adult.—There is no evidence of secretion of any type in the adult during hibernation. This is not to be expected, as during dormancy the adult does not feed.

The Hind-Intestine.

Active adult.—The hind-intestine consists of four parts, the pyloric valve, the ileum, the colon, and the rectum. The tissue layers are the same in all parts, namely:

1. Intima of chitin.
2. Hypodermal epithelium.
3. Basement membrane.
4. Circular muscles.
5. Longitudinal muscles.
6. Peritoneal membrane.

The Malpighian vessels arise just caudad from the end of the mid-intestine and cephalad from the pyloric valve. There are six tubules arising as the spokes of a wheel around the intestine. The epithelial cells at the origin of the tubules are cuboidal in shape and are very small in comparison to the cells of the mid-intestine. (Plate I, Fig. 6).

The pyloric valve is very well developed. Grossly, it is a long structure placed in the tract in a manner similar to that of the "sections" in an orange. There are six of these "sections" and when viewed in cross section they appear as six lobes extending into the lumen of the hind-intestine. (Plate II, Fig. 5). These ridges occur in one form or another all along the proctodaeum.

The layer of chitin is well developed in the pyloric valve.

The epithelium layer consists of rather tall columnar cells closely following the invaginations of the basement membrane.

The most prominent layer in the pyloric region is the layer of circular muscles that is found outside the basement membrane. This layer of muscle is probably the most outstanding muscle layer in the whole alimentary canal, the only other region so greatly muscled is the rectum.

Outside the circular muscle layer are found isolated strands of longitudinal muscles.

The ileum still possesses the vestiges of the lobes of the pyloric valve. The epithelium cells, however, have lost their columnar type, becoming cuboidal. (Plate II, Fig. 8). The circular muscle has reduced in number of fibers, being only approximately half as many as in the pyloric region. This is bordered by isolated strands of longitudinal muscles.

The colon is marked by the entrance of the Malpighian tubules under the peritoneal membrane. (Plate II, Figs. 10, 11.)

The epithelium layer is similar to that of the ileum, though not quite as pronounced.

Outside the basement membrane is an insignificant layer of circular muscles. The longitudinal muscles are not easily distinguishable.

The most striking thing about the colon is the appearance of the Malpighian tubules under the peritoneal membrane. The Malpighian vessels usually consist of a tube, four-celled in cross section, and in the region of the hind-gut the inner border of the tubule is striated. (Plate II, Fig. 6). These vessels enter the small end of the colon as six separate tubules, and follow a fairly straight course down the colon to the point where it begins to bulge. Where the bulge begins, the vessels begin a series of folds or convolutions At no point in their course do the tubules enter the hind-intestine, but wind their way under the outer layer down to the rectum where they come to an abrupt termination. (Plate II, Fig. 12). The winding of the Malpighian vessels under the peritoneal membrane explains the occurrence of more than six sections of tubules in some slides, some single tubules being sectioned more than once. (Plate II, Fig. 9). At no place do the Malpighian vessels branch.

The chitinous intima of the rectum is heavier and more jagged in appearance than in any other portion of the whole digestive tract. (Plate II, Figs. 10, 13).

The epithelium is indistinct, the cell outlines being very difficult to see. The epithelial layer is still thrown into six longitudinal folds.

The most outstanding layer in the rectum is the heavy layer of circular muscles that is found outside the basement membrane

The longitudinal muscle layer is indistinct. Isolated strands are sometimes found intermingled with the circular muscles.

Hibernating adult.—There seems to be no difference in the structure of the hind-intestine of the hibernating adult. However, the diameter of this structure in the hibernating adult is much smaller. It usually becomes filled with structureless waste materials which are probably the indigestible remains of food that are held in this region until the beetle becomes active and once more can rid its system of waste substances.

CONCLUSION.

The purpose of this paper is not to solve for all time the changes in the morphology of the Mexican Bean Beetle during its dormant period, but merely to show and attempt to describe some of the histological differences that occur. A true and complete understanding of this phenomenon lies covered in the combined fields of morphology and physiology. Work along these lines would undoubtedly ferret out the causes and conditions under which this epithelial degeneration takes place, as well as describe more in detail the structures involved over the whole period of dormancy. It need not be said that a vast amount of work can be done along these lines, in other hibernating insects as well as in the Mexican Bean Beetle.

BIBLIOGRAPHY

Becton, Edward M., Jr. 1930. The Alimentary Canal of *Phanaeus vindex* Macl. (Scarabeidae). Ohio Jour. Sci., Vol. XXX, No. 5, pp. 315–323.

Cecil, Rodney. 1930. The Alimentary Canal of *Philaenus leucophthalmus* L. Ohio Jour. Sci., Vol. XXX, No. 2, pp. 120–130.

Comstock, J. H. 1924. An Introduction to Entomology.

Fletcher, Fred Walker. 1930. The Alimentary Canal *of Phyllophaga gracilis* Burm. Ohio Jour. Sci., Vol. XXX, No. 2, pp. 109–119.

Folsom, J. W. and **Welles, M. U.** 1906. Epithelial Degeneration, Regeneration, and Secretion in the Mid-intestine of Collembola. The University Studies, U. of Ill., Vol. II, No. 2, pp. 107–127.

Howard, N. F. and **English, L. L.** 1924. Studies of the Mexican Bean Beetle in the Southeast. U. S. D. A. Dept. Bull. 1234, pp. 1–50.

Imms, A. D. 1929. A General Textbook of Entomology.

Ishimori, Naoto. 1924. Distribution of the Malpighian Vessels in the Wall of the Rectum of Lepidopterous Larvae. Ann. Ent. Soc. Amer., Vol. 17, pp. 75–86.

Potts, S. F. 1927. The Alimentary Canal of the Mexican Bean Beetle. Ohio Jour. Sci., Vol. XXXVII, No. 3, pp. 127–137.

Swingle, M. C. 1930. Anatomy and Physiology of the Digestive Tract of the Japanese Beetle. Jour. Ag. Res., Vol. 41, No. 3, pp. 181–196.

Woods, W. C. 1916. The Malphigian Vessels of *Haltica bimarginata* Say. (Coleoptera). Ann. Ent. Soc. Amer., Vol. IX, No. 4, pp. 391–406.

1918. The Alimentary Canal of the Larva of *Altica bimarginata* Say. Ann. Ent. Soc. Amer., Vol. XI, No. 3, pp 283–314.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Longitudinal section of pharynx, oesophagus, valve, and portion of mid-intestine. Active adult.
Fig. 2. Cross section of anterior portion of ventriculus, showing double splitting of the epithelium layer. Hibernating adult.
Fig. 3. Cross section of crop. Active adult.
Fig. 4. Cross section of posterior portion of ventriculus, showing single splitting epithelium. Hibernating adult.
Fig. 5. Longitudinal section of anterior portion of ventriculus. Hibernating adult.
Fig. 6. Longitudinal section of pyloric region, showing posterior portion of ventriculus, Malpighian tubule attachment, and section of pyloric valve. Active adult.
Fig. 7. Cross section of oesophagus. Active adult.
Fig. 8. Cross section of anterior portion of ventriculus. Hibernating adult.

PLATE II.

Fig. 1. Cross section of ventriculus. Active adult.
Fig. 2. Cross section of posterior portion of ventriculus, showing replacement of cells by nidi. Active adult.
Fig. 3. Longitudinal section of anterior portion of ventriculus. Active adult.
Fig. 4. Cross section of ventriculus, showing secretion. Active adult.
Fig. 5. Cross section of pyloric valve. Active adult.
Fig. 6. Cross section of Malpighian tubule. Active adult.
Fig. 7. Section showing cell in the process of secretion. Active adult.
Fig. 8. Cross section of ileum. Active adult.
Fig. 9. Cross section of colon, showing Malpighian tubules under the peritoneal membrane. Active adult.
Fig. 10. Longitudinal section of colon and rectum. Active adult.
Fig. 11. Enlargement of portion of longitudinal section of colon, showing Malpighian tubule under peritoneal membrane.
Fig. 12. Gross dissection showing arrangement of Malpighian tubules under the peritoneal membrane.
Fig. 13. Gross section of rectum. Active adult.

ABBREVIATIONS.

Anterior portion of Ventriculus—P. VENT.
Basement Membrane—B. M.
Circular Muscle—C. M.
Colon—CO.
Crop—CR.
Epithelium—EPI.
Food—FD.
Ileum—IL.
Intima—IN.
Inner Epithelium—I. EPI.
Longitudinal Muscle—L. M.
Malpighian Tubule—M. T.
Nidus—NI.
Oesophagus—OES.
Oesophageal Valve—OES. V.
Outer Epithelium—O. EPI.
Peritoneal Membrane—PTL. M.
Peritrophic Membrane—P. M.
Pharynx—PH.
Posterior Portion of Ventriculus—D. VENT.
Pyloric Valve—P. V.
Rectum—RE.
Secretion Globules—S. GL.
Spine—SP.

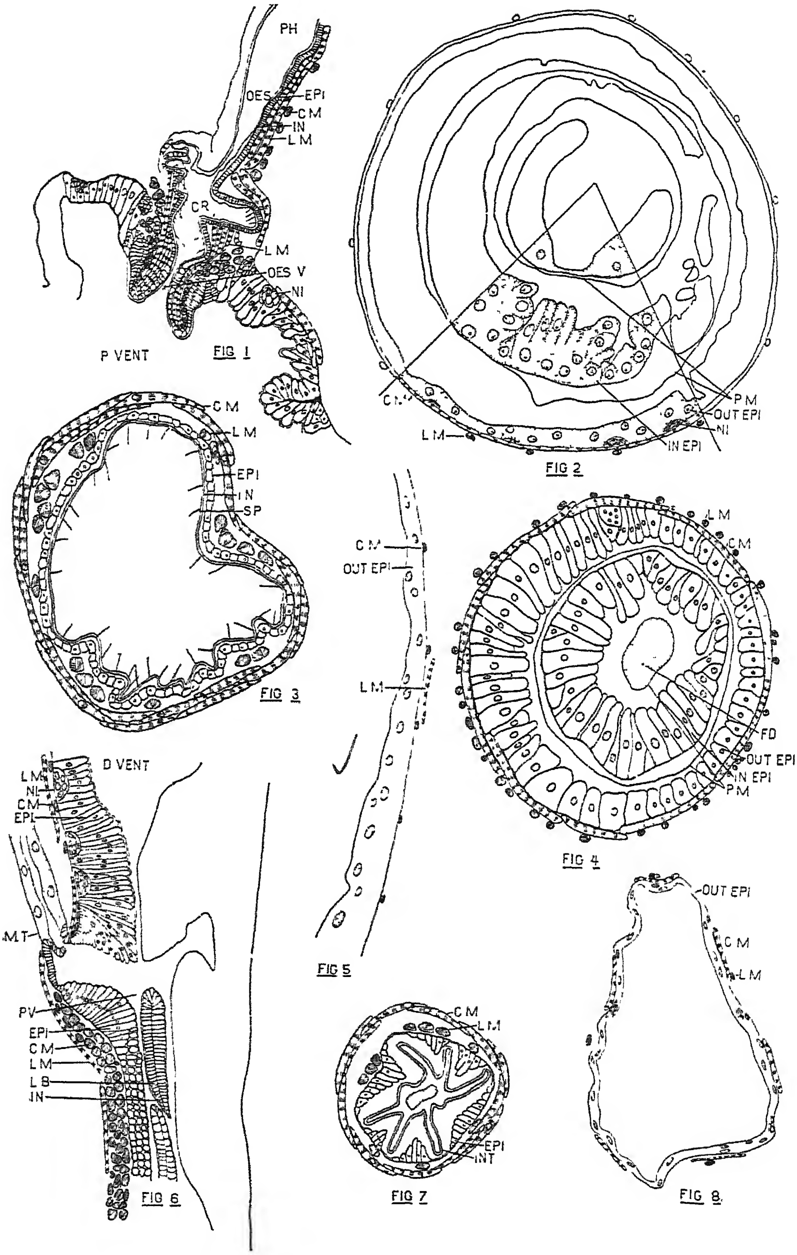
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FIG 1
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FIG 2
C M
L M
EPI
IN
SP
FIG 3
C M
OUT EPI
L M
FIG 5
L M
C M
FD
OUT EPI
IN EPI
PM
FIG 4
D VENT
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PLATE II.

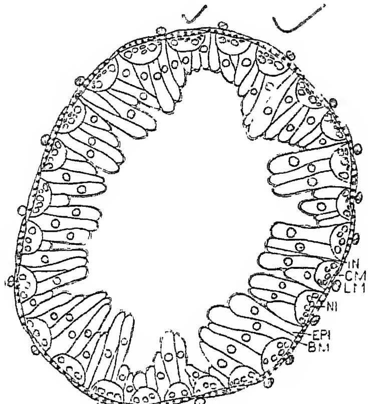
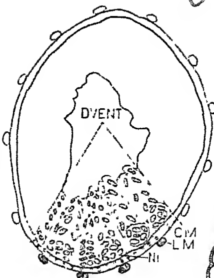


FIG 1



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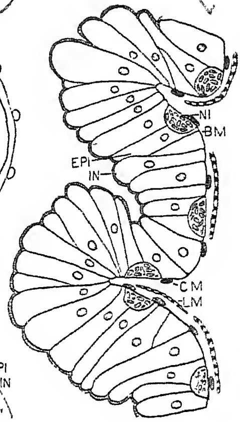


FIG 3

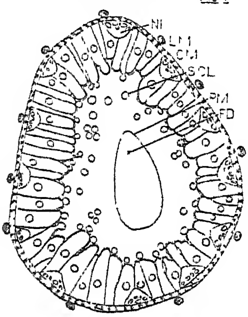
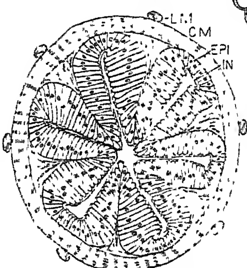


FIG 4



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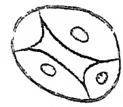

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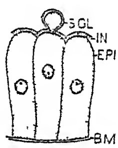
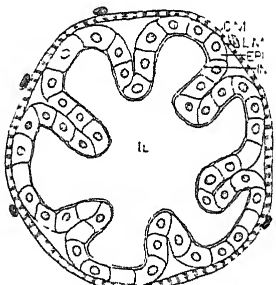


FIG 7



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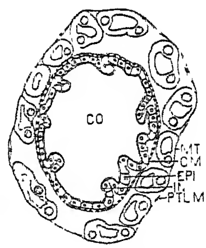

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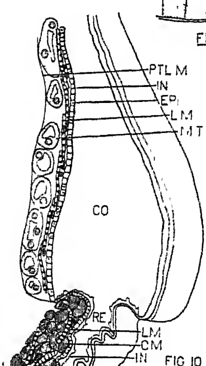
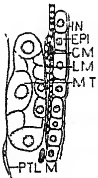


FIG 10



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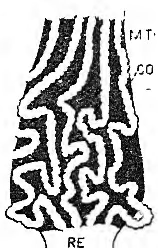

FIG 12

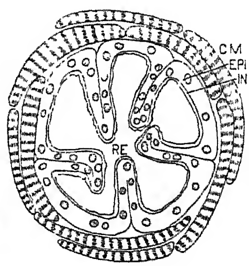

FIG 13

Qualitative Analysis.

This book was first published in 1909, the present revised edition differing from the first edition somewhat in the procedure for getting solid substances into solution, for accomplishing certain cation separations and making certain confirmatory tests using more recently developed methods.

The volume is intended as a brief but adequate treatment of the subject from the modern standpoint and includes sufficient precautionary directions for the student to secure a reasonable delicacy of reaction. So as to stimulate the initiative of the student, very few equations are given. The introductory material is limited to 16 pages, these dealing with: (a) reversible reactions; (b) reactions between ions; (c) dissociation in steps; (d) repression of ionization; (e) equilibrium in a saturated solution; (f) the solubility product; (g) solution; (h) hydrolysis; (i) amphoteric electrolytes; (j) electromotive series; and (k) oxidation and reduction. Students desiring more extensive information are referred to specified pages of Holmes Chemistry and the third edition of McPherson and Henderson's General Chemistry.

Presumably the author presents qualitative analysis as part of a first course in chemistry. It is doubtful as to whether qualitative analysis should in itself be the end in a first course or should merely be a stimulating means to an end—namely, that of a study of the metals and their ions with the non-metals and their ions included so as to give a more completed presentation of elementary qualitative analysis. The reviewer recognizes the fact that most departments of chemistry are service departments and as such are expected to give the students in certain of the professional courses a working familiarity with the procedures and techniques employed in establishing the qualitative composition of the more common inorganic substances.

The author's experience leads him to believe that skeleton outlines of procedure are apt to be followed rather blindly by the student, hence he has given sufficiently full directions and explanatory notes in procedures. This is a meritorius feature of the book. However, it cannot be denied that a much better picture of the relationships within a group of cations is available to the student if a composite procedure is all on one page (or a double page, if necessary).

In several instances a more careful choice or arrangement of words, would enhance the clarity of this Manual. A few examples are: (a) page 4, "NaCl being highly ionized," implies that $BaSO_4$ is not highly ionized; (b) page 11, "Salts of strong acids with strong bases," permits of two interpretations; (c) page 18, "This enables one to work on several parts of an analysis at the same time," (d) page 35, "If bismuth is present it becomes black due to separation in metallic form" (Na_2SnO_2 treatment); (e) "Make first preliminary tests 3;" (f) "Basic Analysis" (Cation Analysis), "Acid Analysis" (Anion Analysis), "Dry Substances" (Solid Substances).

The use of type of different point is generally employed for the purpose of emphasis. On pages 31 and 35, the notes are in smaller type than on page 33, yet all of these are of the same character and of equal importance. Apparently it was the author's desire to have all of the notes on a particular group or sub-group on one page—a feature which warrants some commendation. Frequently suggestions for the teacher and instructions for the student are contained in the same paragraph without even an aside.

Laboratory technique, particularly that involving apparatus, is not pronouncedly stressed, yet the author gives the impression that good technique is essential for rapid dependable work.

There is little evidence for the existence of $As^{\cdot\cdot\cdot\cdot\cdot}$, $Sb^{\cdot\cdot\cdot\cdot\cdot}$, $Sn^{\cdot\cdot\cdot\cdot}$, and perhaps $As^{\cdot\cdot\cdot}$ and $Sn^{\cdot\cdot}$. Ammonia and ammonium hydroxide are sometimes used synonomously—a usage which might be justified as our knowledge of a solution of ammonia in water is limited.

Barring these meticulosities of the reviewer the author has made a worthwhile contribution to the field of introductory qualitative analysis. Many of the books on the market are not only too extensive for students in first year chemistry, but are also too costly to these students—and of this sin the author of this volume cannot be accused.—J. E. DAY.

Qualitative Chemical Analysis of Inorganic Substances. OLIN FREEMAN TOWER, PH. D., Hurlbut Professor of Chemistry in Adelbert College of Western Reserve University. Sixth edition revised. P. Blakiston's Son and Co., Philadelphia. xv+92 pp., 1 Fig.+6 Tables, 23.7 × 16 cm. $1.50.

The Ohio Journal of Science

Vol. XXXII JULY, 1932 No. 4

Annual Report

of the

Ohio Academy of Science

Forty-second Meeting

1932

Organized 1891 Incorporated 1892

Affiliated with the American Association for the Advancement of Science

PUBLICATION COMMITTEE

F. O. Grover Frederick C. Blake E. L. Moseley

Date of Publication, August 10, 1932

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OFFICERS AND COMMITTEES FOR 1932-33

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R. A. BUDINGTON

Vice-Presidents

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Botany: BERNARD S. MEYER
Geology: CARL VER STEEG
Medical Sciences: F. A. HITCHCOCK
Psychology: L. D. HARTSON
Physical Sciences: A. A. ATKINSON
Geography: GEO. D HUBBARD

Secretary

WILLIAM H. ALEXANDER

Treasurer

A. E. WALLER

Executive Committee

Ex-Officio: R. A BUDINGTON, WILLIAM H. ALEXANDER, A. E WALLER
Elective: ALPHEUS W. SMITH, M. E. STICKNEY

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HERBERT OSBORN, *Chairman*, term expires	1935
L. B. WALTON, term expires	1933
GEORGE D. HUBBARD, term expires	1934

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F. O. GROVER, *Chairman*, term expires	1933
FREDERICK C. BLAKE, term expires	1933
E. L. MOSELEY, term expires	1933

Library Committee

MRS. ETHEL M. MILLER, *Chairman*,
In charge of Academy Exchanges and Publications

FREDERICK C. BLAKE, term expires	1933
L. B. WALTON, term expires	1934
F. O. GROVER, term expires	1935

Committee on State Parks and Conservation

E. LUCY BRAUN, term expires	1933
EDMUND SECREST, term expires	1933
EMERY R. HAYHURST, term expires	1933
HERBERT OSBORN, *Chairman*, term expires	1934
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W. E. STOUT, term expires	1934
J. ERNEST CARMAN, term expires	1935
E. L. WICKLIFF, term expires	1935
ROSCOE W. FRANKS, term expires	1935

Academy Representatives on the Joint Administrative Board, Ohio Journal of Science

C. G. SHATZER, term expires	1934
EDWARD L. RICE, term expires	1935

Academy Representatives on the Save Outdoor Ohio Council

Herbert Osborn, term expires	1933
A. E. WALLER, term expires	1933

Nominating Committee for 1933

DWIGHT M. DELONG
ARTHUR T. EVANS
E. M. SPIEKER
SHIRO TASHIRO
HORACE B. ENGLISH
FORREST G. TUCKER
EUGENE VAN CLEEF

REPORT OF THE FORTY-SECOND ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE.

WILLIAM H. ALEXANDER,
Secretary.

INTRODUCTORY.

The Forty-second Annual Meeting of THE OHIO ACADEMY OF SCIENCE occurred at the end of April, 1932, in the ample and commodious halls of historic Ohio Wesleyan University in a wholesome academic atmosphere surcharged with a fine spirit of genuine courtesy and sincere cordiality. It seems safe to say that all members of the Academy who were fortunate enough to attend this meeting came away with more than formal words of appreciation on their lips, rather with a stronger affection and greater admiration for old Wesleyan in their hearts.

One hundred and seventy-two members of the Academy and seventy-six visitors registered. Miss Grace and Miss Lucile Lambert looked after the registration in a most gracious and efficient manner.

The local executive committee, under the fine leadership of Prof. Claude E. O'Neal, certainly did all in its power to anticipate and provide for the requirements of the general and sectional meetings and to see that the visitors were properly and amply cared for in their every need, the lady members and visitors being especially honored by the University Women's Club with a tea on Friday afternoon at Stuyvesant Hall.

Two interesting field trips were arranged for, one for the Geological Section and one for the Zoological Section, the former visiting the Devonian limestone locations in the vicinity of Delaware and the latter the heronry located about ten miles north of the city.

The presence of a considerable number of members of the Central Ohio Physics Club and the Akron Physics Club is noted with much pleasure and their helpful co-operation acknowledged with appreciation.

The Annual Dinner was a notable success, the attendance being surprisingly large, in fact, overtaxed the accommodations and some had to be turned away. A warning for next year! Dr. Edward L. Rice acted as toastmaster and introduced

the various speakers in his usual happy manner. Following a most appetizing dinner delightfully served with the assistance of Ohio Wesleyan's fair students, Dean Smyser was introduced and added his gracious words of welcome to the written message of President Soper (necessarily absent from the city) to which President Smith replied on behalf of the Academy. The greetings being over, President Alpheus W. Smith was then presented and gave the Presidential Address on "Physics and Human Experience," much to the pleasure and profit of all who heard him.

Minutes of the Business Meetings.

First Session: April 29, 1932.

The first business session of the Forty-second Annual Meeting of the Ohio Academy of Science was called to order by President Smith in the Chapel Annex, University Hall, at 9:41 a. m., with a quorum present.

The President announced the following committee appointments:

Committee on Membership—George D. Hubbard and Allen C. Conger.

Committee on Resolutions—Miss E. Lucy Braun, E. H. Johnson and Paris B. Stockdale.

Committee on Necrology—Walter H. Bucher and Walter C. Kraatz.

The reports of the Secretary and the Treasurer were then read, the former was accepted and ordered filed and the latter was referred to the Auditing Committee. Both reports are published in these proceedings.

After the reading of the Treasurer's report and at his suggestion, the following motion was made and unanimously passed:

That the question of Academy accounting system and custody of funds be referred to the Executive Committee with power to make desirable adjustments, and if necessary to recommend amendments to the Constitution and By-Laws, and

That this motion be notice of such amendments to the Constitution and By-Laws as may be necessary in the paragraphs or sections concerning custody of funds and accounting system

The President then called for the election by the Academy of an Auditing Committee, whereupon M. E. Stickney, of

Denison University, Granville, and E. H. Johnson, of Kenyon College, Gambier, were placed in nomination and upon motion, duly passed, the Secretary was instructed to cast the unanimous ballot of the Academy for the persons nominated, which he did and they were declared elected.

The election by ballot of a Nominating Committee was called for and following the precedent of last year, upon motion duly made, seconded and passed, the Secretary was instructed to cast a written ballot for the present seven vice-presidents of the Academy to serve as a Nominating Committee to report at the annual meeting in 1933. The Secretary cast the written ballot of the Academy accordingly and the following persons were declared elected to serve as the Nominating Committee for 1933:

Zoology: DWIGHT M. DELONG, Ohio State University.
Botany: ARTHUR T. EVANS, Miami University.
Geology: E. M. SPIEKER, Ohio State University.
Medical Sciences: SHIRO TASHIRO, University of Cincinnati.
Psychology: HORACE B. ENGLISH, Ohio State University.
Physical Sciences: FORREST G. TUCKER, Oberlin College.
Geography: EUGENE VAN CLEEF, Ohio State University.

The President asked Mr. Dwight M. DeLong to act as temporary chairman of the committee until a permanent organization could be effected.

At this point, it was suggested by the Secretary that in as much as the hour had arrived (10:00 A. M.) for the general scientific session, that the business session take a recess until after the scientific session. This was agreed to and at 10:10 A. M. Mr. O. N. Liming, of the Ohio Agricultural Experiment Station, was introduced and discussed "The Dutch Elm Disease in Ohio" in a very informing manner and closed with an appeal for a general co-operation in the study and location of the disease in Ohio during the current year, as this work by the Experiment Station was seriously handicapped for lack of funds.

The President then advised the Academy that owing to serious illness in the family, Mr. Julius F. Stone, much to his regret, could not be present and give his address on the Mayan Civilization of Central America as announced.

Mr. N. E. Oltman, a student at Oberlin College, introduced by Prof. F. O. Grover, was given an opportunity to describe

to the Academy an instrument of his invention for the accurate quantitative determination of chlorophyll.

The next item on the scientific program was a moving picture showing "The Treatment of Osteomyelitis with Blowfly Larvae," presented and discussed by Dr. D. F. Miller and Dr. E. H. Wilson, of Ohio State University. This was an outstanding and most informing feature of the program and greatly enjoyed by all who saw and heard.

At 11:00 A. M. the business session was resumed. The Secretary read the report of the Executive Committee and under new business the several recommendations contained in the report of the Executive Committee were considered and all approved except the one as to place of meeting for 1933; this together with the time of meeting and the selection of representatives on the Council of the American Association for the Advancement of Science, the State Academies Conference of the A. A. A. S. and the Save Outdoor Ohio Council were referred to the Executive Committee with power.

Regarding recommendation numbered 3 (the omission of the membership list from the Proceedings), the Secretary pointed out that this would require an amendment to the By-Laws (Chapter VI, Section 4). Upon motion duly passed by a majority of those voting it was agreed that the By-Laws be amended so as to require the publication of the membership list at five-year intervals.

The report of the Trustees of the Research Fund was read by the chairman, Dr. Herbert Osborn, and referred to the Auditing Committee.

At 12:10 P. M. the business session was adjourned until 9:00 A. M. Saturday, April 30, 1932.

Second Session: Saturday, April 30, 1932.

The Academy was called to order by the President at 9:10 A. M. with a quorum present.

The first item of business at this session was the reading of the report of the Library Committee by its chairman, Mrs. Ethel M. Miller. This report was obviously enjoyed and appreciated by the Academy and was referred to the Auditing Committee.

The report of the Committee on State Parks and Conservation was read by the chairman, Dr. Herbert Osborn. Following

the reading of this report, Doctor Osborn proposed and the Academy adopted the following resolutions:

1. That we favor the passage of H. R. Bill No. 6478 and substitute Senate Bill No. 1704 to provide for Water Conservation Survey in Ohio.
2. That we favor extension of Water Conservation program.
3. That we especially commend the programs of education in conservation and preservation of wild flowers as outlined by the Wild Flower Preservation Society and the Central Ohio Anglers' and Hunters' Club.
4. That we favor the setting apart of suitable areas in State Parks as wild life sanctuaries to be free from disturbance of natural conditions and not open to picnic or camping parties, or to provision of roadways or paths.
5. That we favor legislation to protect hawks and owls except to the right of any citizen to control them when in the act of destroying property, and that the use of pole traps be made illegal.

Reports of special committees were now called for and presented in the following order:

Committee on the Election of Fellows, by the Secretary.
Committee on Membership, by Geo. D. Hubbard.
Committee on Necrology (informal by the President; committee asked to submit a full report later to the Secretary).
Committee on Auditing, by M. E. Stickney.
Committee on Junior Scientific Effort in Ohio, by C. G. Shatzer.
Committee on the Academy's Relation to the Ohio Journal of Science, by E. L. Rice.
Committee on Publications, by F. O. Grover.
Committee on Administrative Board, by E. L. Rice.
Committee on Nominations and Election of Officers, by W. J. Kostir.
Committee on Resolutions, by E. H. Johnson.

The above reports will be found published in full elsewhere in these Proceedings.

Under the head of unfinished business two motions were made and passed:

(1) That Dr. Herbert Osborn and Prof. James A. Nelson be the duly appointed delegates of the Academy to the Fifth International Congress of Entomologists at Paris, France.

(2) That the question raised by the chairman of the Library Committee as to whether the funds received from the sale of the Proceedings should be credited to the Academy or to the Journal be referred to the Executive Committee.

Adjourned *sine die*, 10:55 A. M.

REPORTS.

Report of the Secretary.

DELAWARE, OHIO, April 29, 1932.

To the Ohio Academy of Science:

Again, briefly!

Of course, the first serious task of the secretary following an annual meeting is to see that the proceedings of the meeting are promptly put into shape for the Publications Committee and the printer, not forgetting the Editor of the OHIO JOURNAL OF SCIENCE. And this is no small task, be assured, now that we include in addition to the usual *minutes* and *reports* a very considerable number of *abstracts.* The secretary freely admits that he is *deliberately,* and perhaps with some degree of "malice aforethought," seeking to unload much of the work of collecting and editing the abstracts on to the shoulders of the unsuspecting (?) vice-presidents! And he is glad to report, *with appreciation*, that he is succeeding grandly thus far!

As you probably know, the proceedings of the Oxford Meeting were published as the July issue of the OHIO JOURNAL OF SCIENCE (Number 4, Volume XXXI) under the new plan of publication of that journal.

A report of the Oxford meeting was also prepared for and published in *Science.*

Certificates of election were prepared and sent to all those elected to fellowship at the Oxford meeting

A new form on which to nominate members to fellowship in the Academy was prepared, printed and distributed upon request, as requested by the Committee on the Election of Fellows at the Oxford meeting.

Routine matters of varying degrees of importance required considerable time and attention from the closing up of the work of the annual meeting of last year and the beginning of negotiations for the ensuing annual meeting—seemingly a very short time! The details were taken care of as promptly and as efficiently as possible under the existing, living conditions of the Secretary.

Of course an enumeration of these minor details is neither necessary nor wanted, but there is one accomplishment of the year in which the Secretary had a very pleasing though minor part which is of sufficient general interest, it is believed, to warrant mention at this time, namely, the organization of a new section, the *Section of Geography.* Some twenty persons (see following) expressed an interest in such a section and judging from the initial program offered at this meeting it is a rather lusty infant and is sure to be heard from in the future.

Finally, Mr. President and fellow officers and members of the Academy, permit the Secretary to record and express his very high appreciation of your unfailing patience, courtesy and co-operation during the year now ended.

Respectfully submitted,

WILLIAM H. ALEXANDER,
Secretary.

Supplemental

A list of persons who signified an interest in a Section of Geography within the Ohio Academy of Science.

C. G. Shatzer, Wittenberg College.
W. A. P. Graham, Ohio State University.
*W. R. McConnell, Miami University.
Frank J. Wright, Denison University.
Carl Varvel, Ohio State University.
Wilbur Stout, Ohio Geological Survey.
Paris B. Stockdale, Ohio State University.
Roderick Peattie, Ohio State University.
*C. E. Cooper, Ohio University.
A. J. Wright, Ohio State University.
*W. M. Gregory, Western Reserve University.
Carl Ver Steeg, Wooster College.
*L. B. Karnes, Ohio State University.
Eugene Van Cleef, Ohio State University.
A E. Waller, Ohio State University.
Fred Carlson, Ohio State University.
E. N. Transeau, Ohio State University.
G. H. Smith, Ohio State University.
C. C. Huntington, Ohio State University.
Clarence Kennedy, Ohio State University.

Report of the Executive Committee.

Delaware, Ohio, April 29, 1932.

To the Ohio Academy of Science:

The Executive Committee has met four times during the year, three times as an *executive committee* and once in joint session with the vice-presidents as a Committee on the Election of Fellows.

At the first of these meetings, held in the office of the secretary on December 12, 1931, Dr. Herbert Osborn, editor of the Ohio Journal of Science, was present by invitation and joined in the deliberations of the committee. The following items of business of general interest to the Academy were presented, discussed and agreed to, viz.:

1. That the treasurer be authorized to pay the sum of three hundred dollars ($300 00) toward the printing of the Proceedings of the Oxford meeting (the Forty-first Annual Meeting).
2. That the Publications Committee be requested to limit all abstracts to 200 words.
3. That it is the sense of the Committee that the publication of the membership list should hereafter be omitted from the published Proceedings (except as ordered by the Executive Committee) and that a mimeographed list be supplied to officers of the Academy.
4. That a *Section of Geography*, with Dr. Eugene Van Cleef as the provisional vice-president, be authorized, subject to the final approval of the Academy. This action was based on the expressed interest in such a section of the following persons: (See attached list).

*Non-members.

5. That the applications for membership in the Academy of the following six persons presented by the secretary be approved and recommended to the Academy: Dr. Stanley A. Cain, Fred S. Darling, Ralph H. Davidson, Vincent R. Peterson, Winford L. Sharp and Charles W. Super (90 years old).

6. That Dr. Herbert Osborn and Dr. A. E. Waller be the Academy representatives on the Save Outdoor Ohio Council.

7. That Dr. Herbert Osborn be the Academy representative on the Council of the A. A. A. S. and the State Academies Conference of the A. A. A. S. at the New Orleans, La., meeting.

8. That the annual meeting for 1932 be held during the Easter holidays, or spring vacation, as may best suit the entertaining institution, the place to be decided upon later, after necessary negotiations by the secretary. (Needless to say it was later decided to accept the invitation of Ohio Wesleyan University.)

9. That the action of President Smith in appointing Professors E. L. Rice and C. G. Shatzer on the Administrative Board of Ohio Journal of Science and of Professor E. L. Rice as chairman of the Special Committee on the Relations of the Ohio Academy of Science and the Ohio Journal of Science, in securing the approval of a majority of the committee to the working plan on the relations of the Ohio Academy of Science to the Ohio Journal of Science be approved.

10. That the new form prepared by the secretary on which to nominate fellows be approved.

At the second meeting of the committee held on March 19, 1932, in the office of the secretary, the applications for membership of fourteen persons were submitted by the secretary and approved subject to ratification by the Academy. The names are included in the list submitted herewith.

The action of the secretary in appointing Prof. Dwight M. DeLong, of Ohio State University, as vice-president of the Section of Zoology, vice J. Paul Visscher, resigned, was approved.

The details of the general program of this (Delaware) meeting were considered at length, agreed upon and recommended to the Program Committee about as they appear in the printed program before you.

The third meeting of this committee was held last evening in joint session with the vice-presidents as a Committee on the Election of Fellows and the actions taken at this meeting will appear in another report.

The fourth and last meeting of the committee was held last evening following the adjournment of the joint session just mentioned and the following items of business were transacted:

(1) Upon the request of Prof. E. L. Rice, Prof. August F. Foerste was appointed to assist in the completion of the audit of the Treasurer's report of 1930–1931, instead of Prof. J. E. Hyde, absent on account of illness.

(2) That the Executive Committee recommend the acceptance of the very cordial (second) invitation of Ohio University, Athens, through its President, to hold the annual meeting of 1933 at that institution.

(3) The final report of the Auditing Committee on the Treasurer's report of 1930–1931 was received, accepted and ordered filed. See page 274.

Respectfully submitted,

William H. Alexander,
Secretary.

Final Report of the Auditing Committee.

(For the Year 1930–1931)

April 28, 1932.

To the Executive Committee, Ohio Academy of Science.

GENTLEMEN:—The audit of the Treasurer's accounts for 1930–31 was left incomplete, owing to the absence of certain data deemed necessary by the Auditing Committee, Messrs. Hyde (chairman) and Rice. A final report was to be presented to the Executive Committee; but, owing to the illness of the Chairman, this has not been done.

At the request of Mr. Rice, Mr. Foerste was requested by the Executive Committee to co-operate in the completion of the audit.

The lacking data have been examined, especially a statement concerning the invested funds, and we hereby report the accounts as found correct in substance.

We wish to suggest, however, that the form of the accounts is not satisfactory, and to express our judgment that the Executive Committee should consider the advisability of employing a trained accountant to set up a simple form of bookkeeping for the assistance of the Treasurer.

We wish further to suggest that it is very desirable to arrange (with change of by-laws or constitution if necessary) for the audit of the Treasurer's accounts prior to the time of the Annual Meeting, when the auditors can work carefully and thoughtfully. This work might well be done by a trained accountant rather than by a committee of members of the Academy; in fact it is a fair question whether the time has not come when the entire accounting of the Academy, including that of the Research Fund, should be put in professional hands.

AUG F. FOERSTE,
EDWARD L. RICE,
Committee.

MEMORANDUM.

Letters from the Treasurer and the Secretary under dates of April 22 and 23, 1932, examined and appended, as furnishing the necessary additional data.

EDWARD L. RICE.

Report of the Treasurer.

(For the Year 1930–1931.)

RECEIPTS.

Cash balance on hand April 14, 1930	$1,614 32
Receipts from sale of publications	76 75
Dues from members, back dues collected	1,282.48
Received from A A. A. S.	120 00
Two Life Memberships in the Academy.	100 00
Total Receipts, Exhibit A	$3,193 55

DISBURSEMENTS.

L. H. Tiffany, expenses as chairman of the Botany Section, 1930	$ 4 47
W. H. Alexander, Secretary's Honorarium	100 00
A. H. Peterson, Chairman, Local Committee, for 1930 meeting	19 00
C. E. Wilson, posters for 1930 meeting	6 00
University Press, Academy dinner tickets for 1930	1 95
Martin L. Reymert, expenses as chairman of Psychology Section, 1930.	14 05
C. E. Wilson, signs, wood frames and sticks	10 00
University Press, maps of campus for 1930 meeting	2 60
Spahr and Glenn, addressed return envelopes	2 50
Spahr and Glenn, Proceedings of Thirty-ninth Annual Meeting	355 50
O. S. U., flowers for Academy dinner.	10 00
Rose McCabe, secretarial services for Treasurer	29 00
Spahr and Glenn, for 1,000 copies of Proceedings of the Fortieth Annual Meeting	370 50
Spahr and Glenn, for letterheads and binding Volume 7	16 50
W. H. Alexander, Secretary, for postage	30 96
Save Outdoor Ohio League, two memberships	24 00
P. B. Stockdale, expenses in connection with surveying for field trip of Geology Section	31 80
B. S. Meyer, Business Manager, Ohio Journal of Science, for 480 members of the Ohio Academy of Science	720 00
Columbus Postmaster, 1,000 stamped envelopes	22 16
F. C. Waite, railroad fare for attendance at two executive meetings	24 08
James P. Porter, transportation expenses to executive meeting	5.44
C. G. Rogers, transportation expenses to executive meeting	7 32
J. H. Hoskins, transportation expenses to executive meeting	5 00
Spahr and Glenn, for preliminary announcements, post cards, etc	27 25
Spahr and Glenn, for statements and envelopes	6 75
J. H. Hoskins, for work on program committee	7 80
C G. Rogers, for work on program committee	7 32
Columbus Postmaster, for stamps for circularizing members of the A. A. A. S. (700 1½-cent stamps)	11 25
Check returned	2 50
Total Disbursements, Exhibit B	$1,875 70
Receipts	$3,193 55
Disbursements	1,875 70
Cash balance on hand March 30, 1931	$1,317 85

The review of the financial transactions of the Ohio Academy of Science is more than an accounting for received and spent. It presents a concise picture of the activities and growth of the Academy. In spite of drouth, depressions in agriculture and in the business world, it is still possible to present a report of increasing interest in the work of the Academy.

The total number of paid up members for the current year is 480 as compared with 371 for the previous year, an increase of 109 members. This can be accounted for in part by an increase in the number of high school teachers and graduate students who have in the past year become members of the Academy. In spite of the reiteration of its aims to include all persons interested in Science who wish to become members of the Academy, the officers continually find persons who express surprise that membership in the Academy is not a matter of special invitation. We have a membership committee that functions definitely at our meetings. The executive committee has not succeeded in developing

a mechanism whereby prospective members may be canvassed throughout the year. Will the reader of this report therefore aid the Academy by personally canvassing and proposing one new member. Two attempts have been made by the Treasurer to advertise the Academy. At the 1930 Educational Conference held at Ohio State University, the advantages of the Academy were explained in meetings of the Physical and Biological conferences and a table was provided in connection with biological demonstrations, at which was displayed the volumes of the Ohio Journal of Science and the Proceedings of the Academy. During the past week a circular letter was mailed to all members of the A. A. A. S. in Ohio who are not members of the Academy. Both methods have resulted in the addition of enough members to warrant continuation.

The other sources of income for the Academy are the sale of publications, details of which are reported by the Academy Librarian, and the allowance made to the Academy from the A. A. A. S

Two memberships in the Save Outdoor Ohio League appearing this year are tangible evidence of the Academy's interest in a field where it has long been the pioneer and even the only organization devoted to the protection of natural resources and wild life.

Respectfully submitted,

A. E. WALLER,
Treasurer.

TREASURER'S LETTER.

COLUMBUS, OHIO, April 22, 1932.

To the Auditing and Executive Committees, The Ohio Academy of Science.

GENTLEMEN:—The absence of two cancelled checks temporarily misplaced by the bank last year at the time of filing the report of the treasurer at the annual meeting caused a good deal of worry. These checks later came to light and are available for examination by the auditing committee. At the time of the meeting last year the arrangement was made for the auditing committee to meet with the executive committee and present its report. To my knowledge this has not been done. The situation has both a serious and an amusing aspect if the committee cannot file a report without the check, especially since they appear on the bank's statement, but the treasurer found little humorous relief in the situation.

At the same time a more important thing was brought up, namely, that of a complete résumé of the financial reports beginning before the present treasurer's accession to office. Let it be stated that the treasurer never sought the responsibility of looking after the Academy's funds and has tendered his resignation annually because of a feeling of inadequacy in bookkeeping. The reports show that expenditures and income have tallied, but failed to show the source of all the items of income in a satisfactory manner. The treasurer was given some suggestions which have been put into effect. If, however, a more elaborate system of bookkeeping is desired the treasurer would have to ask for assistance in making and keeping the records. The time at his disposal does not permit any but the simplest arrangements for collecting and recording the dues, etc.

The solidarity of the Academy's financial position is attested by the accumulation of a substantial reserve fund all at present in United States Government Bonds. This type of investment was chosen at the discretion of the Treasurer several years ago after the original purchase of a Building and Loan certificate. The return from the government bonds is not high, but the measure of safety has certainly justified the investment. These bonds being Liberty Bonds will possibly be called for retirement before the close of the year as the government expects to refinance with bonds at a lower interest rate. Since the turn of the investment is a necessity, it might be wise for the Executive Committee to inquire about reinvest-

ing our fund in substantial common stocks, or in a British type Investment Trust, or in high grade Municipal bonds. The reserve fund may have to be drawn on slightly to meet current expenses, but there should still be around $1,500.00 available at the present time for permanent investment.

Respectfully submitted,

A. E. WALLER, *Treasurer.*

SECRETARY'S LETTER.

COLUMBUS, OHIO, April 23, 1932.

To the Auditing and Executive Committees, Ohio Academy of Science.

GENTLEMEN:—In connection with the Treasurer's letter of the 22nd instant, permit the undersigned to say that he in company with the Treasurer this day visited the Safety Deposit Vaults of the Huntington Bank Building and inspected the bonds now on deposit in the Ohio Academy of Science safety deposit box. We found there six (6) Fifty Dollar U. S. Bonds and fourteen (14) One Hundred Dollar Bonds with coupons attached, or a total of $1,700.00 in interest bearing U. S. Bonds.

The two cancelled checks, one for $7.80 in favor of J. Hobart Hoskins, and the other for $11.25 in favor of James R. Geren, Postmaster, Columbus, Ohio, referred to in the Treasurer's letter, are being forwarded this date to the chairman of the Auditing Committee, Prof. E L Rice, Delaware, Ohio. It would seem this matter can now be completely and promptly cleared up and all minds put at ease.

Furthermore we think it only fair to suggest that the existence of an available fund of $1,700.00 accumulated since the present Treasurer came into office is proof positive that the financial interests of the Academy have been in safe hands and the financial policies followed obviously wise and sound. The Academy should know this.

Cordially,

WM. H. ALEXANDER, *Secretary.*

Report of the Treasurer.

(For the Year 1931–1932)

DELAWARE, OHIO, April 28, 1932.

To the Executive Committee, Ohio Academy of Science.

GENTLEMEN:—Each year your treasurer has been able to report the sound financial condition of the Academy. Each year he has offered suggestions for uses to be made of the Academy's funds. During this time he has had the pleasure of seeing the reserve funds increase, but at no time has any particular action been taken on his suggestions While the size of the Academy has increased during the period of his treasurership the expenses of its operation have been held to a low figure and each item of expenditure carefully checked. Looking over the record of expenses, by far the largest item is for printing, both in the form of subscriptions to the Ohio Journal of Science and the Proceedings of the Academy, its programs, notices and announcements. This is as it should be. At least, it should until the Academy can some day look forward to having a home of its own with library and museum facilities, activities on an entirely different scale from any as yet modestly foreshadowed in our Academy, but already in existence in certain more fortunately endowed scientific societies. It is with the future uses in mind that the Treasurer has been accumulating a surplus fund out of current income that will make a small beginning for the Academy of the future.

However, the responsibility for looking after this fund should not be entirely in the hands of the Treasurer, but the Executive Committee should devise a way to supervise it. Similarly the Research Fund, nominally in the hands of the Treasurer, but actually not administered by him, should be so treated. It would be desirable if the Academy would hold a business meeting apart from those connected with the annual meeting or in preparation for it. Probably it would be desirable for the Academy to have a certified Accountant set up a system whereby the several funds of the Academy could be managed in the simplest possible manner.

It is quite obvious to all of us that the accumulation of unexpended reserves or the accumulation of life memberships will never permit the Academy to increase its capital resources at a very great rate. It has occurred to the Treasurer that we might attempt to interest some of the members and their friends in aiding the Academy by money gifts. Perhaps this sounds optimistic at this period of financial change, but it is in just such times that a newer and often better concept of money values is likely to appear. One method of accumulating money that would spread the cost to the donor over a number of years would be by purchase of life insurance policies with the Academy as beneficiary. It is just because we have a small start toward a fund that I believe we can go to our members and ask for aid.

Respectfully submitted,

A. E. WALLER,
Treasurer.

TREASURER'S REPORT.

RECEIPTS.

Cash balance on hand March 30, 1931	$1,317.85
Receipts from sale of publications	135 00
Received from A. A. A. S.	141 00
Dues from members, back dues collected	1,445 00
Interest from Bonds	58 38
Refund on check for bonds	80.31
Total Receipts, Exhibit A	$3,177 54

DISBURSEMENTS.

James P. Porter, expenses for Program Committee for 1931 meeting	$ 5 44
L. W. Taylor, expenses for Program Committee for the 1931 meeting	8 52
Irona Smith, mimeographing letters to A. A. A. S. members, 1931	5.00
Rose McCabe, clerical help, sending letters to A. A. A. S. members	5 50
Frank J. Wright, expenses for Program Committee for 1931 meeting	3 60
Huntington National Bank, safety deposit box for 1931	3 00
O. S. U. General Storeroom, envelopes, cards, etc	2.23
Spahr and Glenn, for stationery	12 00
W. J. Kostir, expenses for Vice-President of Zoology Section for 1931 meeting	8 40
W. H. Alexander, Secretary's Honorarium	100 00
W. H. Alexander, clerical help, telephone calls, telegrams, etc	34 50
Frank J. Wright, expenses for Vice-President, Geology Section for 1931	12 00
Check returned	2 50
Banco Ohio, U. S. Treasury Bonds	857 86
Check returned	7 50
Spahr and Glenn, for printing programs	101 66

Save Outdoor Ohio Council, two memberships	24 00
Bernard S. Meyer, Ohio Journal of Science, for 505 members in the Academy for 1931 at $1.50 each	757 50
James P. Porter, expenses for Psychology Section for 1931 meeting	15 00
August Foerste, expenses attending Executive Committee meeting, 1931	2 25
Columbus Postmaster, 1,000 stamped envelopes	22 16
B. S. Meyer, Business Manager, Ohio Journal of Science, for Proceedings.	300 00
Check returned	2 50
Irona Smith, mimeographing letter regarding dues	2 00
Spahr and Glenn, for 600 postal cards regarding 1931 meeting, and 200 application for membership blanks	16 50
Spahr and Glenn, for Preliminary Program for 1931	12 00
Roof Stenographic Service, envelopes and postage on preliminary announcements for 1931 meeting	22 53
Spahr and Glenn, Fellowship blanks, statements and envelopes	12 25
W. H. Alexander, postage, long distance calls, envelopes	14 20
August Foerste, expenses for Executive Committee meeting for 1931	2 25
Huntington National Bank, for safety deposit box for 1932	3 00
Rose McCabe, secretarial services for Treasurer from April, 1931, to April, 1932	27 50
Herbert Osborn, for Research Fund	100 00
B. S. Meyer, Ohio Journal of Science, for 300 members in the Academy for 1932 at $1.50 each	450 00
Total Disbursements, Exhibit B	$2,955 35
Receipts	$3,177 54
Disbursements	2,955 35
Cash balance on hand April 25, 1932	$ 222 19

Report of the Auditing Committee.

DELAWARE, OHIO, April 29, 1932.

To the Ohio Academy of Science:

We have examined the Treasurer's Report to the Ohio Academy of Science for April 28, 1932, together with all cancelled checks and the statement of all deposits with the Huntington National Bank of Columbus, Ohio, and find the report correct.

Respectfully submitted,

M. E. STICKNEY,
E. H. JOHNSON,
Auditing Committee.

Report of the Trustees of the Research Fund.

DELAWARE, OHIO, April 29, 1932.

To the Ohio Academy of Science:

During the past year no grants to individuals have been made as it seemed desirable to hold the funds available for possible readjustments or contingencies in investment. The following summary of the account for 1931–32 shows an invested fund of $1,737.50 and a balance in uninvested account subject to check of $137.80.

SUMMARY OF ACCOUNT, 1931-32.

RECEIPTS.

Balance from checking account, April 1, 1931	$ 150.86
Interest receipts from invested funds	25 00
Life memberships	100 00
Total	$ 275 86

EXPENDITURES.

By transfer to invested fund	$ 137 50
Bank service charge	.50
Balance in checking account	137 86
	$ 275.86

SUMMARY OF ASSETS.

Invested Funds, Bonds and Stock Certificates	$1,737 50
	137.86
Total	$1,875.36

Interest payments on bonds held were temporarily suspended, but have been restored on a reduced interest basis with new bonds, and officers of the Ohio National Bank are confident that the bonds are fully secured and that there is hope that the back interest will be paid.

Respectfully submitted,

(Signed) HERBERT OSBORN,
L. B. WALTON,
G. D. HUBBARD,
Trustees.

Report of the Auditing Committee.

DELAWARE, OHIO, April 30, 1932.

To the Ohio Academy of Science:

We have examined the report of the Treasurer of the Research Fund together with all bank statements and find the report correct.

M. E. STICKNEY,
E. H. JOHNSON,
Auditing Committee.

A Supplemental Report by the Trustees of the Research Fund.

With the growth of the Research Fund it seems desirable to clarify certain provisions of the Constitution and By-Laws which seem to have been overlooked in the handling of Research Funds.

The Trustees of the Research Fund were originally elected at the eighth annual meeting, December, 1898, when it was announced by Professor Lazenby that "Emerson E. McMillin had offered $250 to the Trustees of the Academy * * *," and an amendment to Article of the Constitution was proposed, and subsequently adopted at the annual meeting in 1899, reading, "There shall be a Board of Trustees consisting of three members; one elected for one year, one for two

years, and one for three years. It shall be the duty of this Board of Trustees to act as custodians of all property of the Academy and to administer all funds received for original investigation and research."

While later action provided for care of other properties, the Research Fund has remained continuously in charge of the Trustees of the Research Fund, and it appears that in later amendments of the Constitution and By-Laws this condition was overlooked.

Thus in the revised Constitution and By-Laws adopted November 28, 1908, and further amended in 1920, it is specified, Article 4, Section 11: "The Treasurer shall have custody of all funds of the Academy."

Article 4, Section 14: "The Trustees of the Research Fund shall be three in number. They shall have charge of the allotment and distribution of the income or of the principal of the Research Fund."

In references to Life Memberships, By-Laws, Chapter 1, Section 2, "The sums paid in commutation of dues shall be invested, and the interest used for the ordinary purposes of the Academy during the payer's life, but after his death the sum shall be converted into the Research Fund."

The custom of Research Funds being received and handled by the Trustees, which prevailed at the start was evidently continued without question after the adoption of the statement of duties of the Treasurer and might be interpreted to mean that these funds were not counted as current Academy funds that should be in his hands. It was the case at time of death of Dr. Mendenhall, while he was chairman of the Trustees, and after which his accounts came into the hands of the present chairman.

Also, it has been the custom and I think the general understanding that life memberships are added to the research fund though the amended statement seems to intend otherwise.

We recommend, therefore, that the Trustees with the Executive Committee (of which the Treasurer is a member) be authorized to interpret these apparently contradictory clauses and if deemed necessary to recast the paragraphs to make their observance harmonious.

If it is desired that the Trustees be responsible for custody as well as administration of Research funds, it will be necessary only to amend Article 4, Section 11 by insertion of "except funds in charge of Trustees of the Research Fund." If desired that the Treasurer, who is under bond to amount of $500, have this duty, an order for transfer and provision for maintenance of separate account is needed. Also decision as to disposition of Life memberships is desirable. The constitution does not specify "life members," but the provision for commutation of dues is the basis for use of this term.

Report of the Library Committee.

Columbus, Ohio, April 28, 1932.

To the Ohio Academy of Science:

The Library Committee presents the following report:

The members of this committee have considered several matters during the year both by letters and in conferences.

The work of the chairman has been largely routine and has consisted of changing addresses for the mailing list, posting separate issues to members and exchanges, requesting exchange publications that had failed to arrive, and correspondence on various matters. The members of the Academy have been unusually careful about supplying correct addresses this year, so that the mailing list seems to be in a very satisfactory condition at the present time.

In accordance with the decision made last year not to publish the Proceedings of the Ohio Academy of Science as a separate publication, but only in the OHIO JOURNAL OF SCIENCE, the mailing lists of the Academy and the Journal were combined in July, 1931. So for the first time there is lacking from this annual report the statement that the Proceedings of the previous year had been mailed to all the members and exchanges of the Academy. The five standing orders for the purchase of the Proceedings as a separate set were unavoidably lost.

The charter granted by the State of Ohio in 1892 to the Ohio State Academy of Science and the later amendment authorizing the elimination of the word "State," were found in the University Library during the summer of 1931. They have been given to the Secretary of the Academy for preservation.

The supply of the printed lists of available publications became exhausted recently. A new supply has been mimeographed at lest cost than if it had been printed and is just as satisfactory.

The sum of $89.40 for the sales of 1930–1931 was not given to the Treasurer of the Academy until January 6, 1932. The delay was due mostly to the widespread difficulty in withdrawing money from building and loan companies. In addition, the sum of $45.60 has been given to him on the sales account for 1931–1932, making a total of $135.00 transferred from the library fund to the general fund within the last few months.

The sales for the past year amounted to $87.45. The last annual report stated that a complete set of the Proceedings had been sold to a college library. The sale of another nearly complete set is reported this year. The price of a set makes a substantial addition to the total amount of sales. No more complete sets can be sold unless some copies of Special Paper No. 15, Prof. Schaffner's "Trees of Ohio and Surrounding Territory," can be found somewhere or returned by individual owners.

An examination of the sales shows that 129 items were sold in 44 sales, as against 166 items in 56 sales for the preceding year. There were 37 fewer publications sold, but the total amount is nearly as much, lacking only $1.95. This is due to the fact that the papers which were most in demand were the highest priced ones, having been Prof. Jones' "Birds of Ohio" and Dr. Osburn's "Fishes of Ohio," selling for $2.00 and $1.00, respectively. Eleven copies of each were sold. Next in demand were Prof. Hine's "Tabanidae of Ohio," Max Morse's "Batrachians and Reptiles of Ohio," and Dr. Stover's "Agaricaceae of Ohio," with 7 copies each. Eight of the eleven copies of the "Fishes of Ohio" were sold last summer at the Franz Theodore Stone Laboratory

at Gibraltar Island to the students in Dr. Osburn's Ichthyology class. A number of copies had been taken up there for this particular purpose and results were not disappointing. The same result may occur again this year.

Only 5 of the 44 sales were made to people in Columbus, 20 to those in other cities in our own State, and 19 to persons residing in twelve different States. These States extend over the greater part of the whole country except the south and southeast, being Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, West Virginia, Indiana, Michigan, Minnesota, Washington, Arizona and Texas.

The following financial report is submitted:

RECEIPTS.

Cash balance on hand April 2, 1931	$ 83 49
Collected on 1930–1931 sales	30 90
Sales for 1931–1932	87 45
Bank dividends for 1931	5 61
Total Receipts	$207.45

EXPENDITURES.

A. E. Waller, Treasurer, for sales, 1930–1931	$ 89 40
A. E. Waller, Treasurer, on account, 1931–1932 sales	45 60
Government two mill tax	.30
Total expenditures	$135 30

Balance in bank April 28, 1932	$ 70 55
Cash on hand	1 00
Outstanding accounts	.60
Expenditures, 1930–1932	135.30
Total	$207.45

SUMMARY OF ASSETS

Unexpended balance on 1931–1932 sales	$ 41 85
Accumulated bank dividends, 1926–1931	30.30
Total assets	$ 72.15

Respectfully submitted,

ETHEL M. MILLER,
Chairman.

Report of the Auditing Committee.

DELAWARE, OHIO, April 30, 1932.

To the Ohio Academy of Science:

We have examined the Librarian's Financial Report, together with all bank statements and cash on hand, and find the report correct.

Respectfully submitted,

M. E. STICKNEY,
E. H. JOHNSON,
Auditing Committee.

Report of Committee on Publications.

DELAWARE, OHIO, April 30, 1932.

To the Ohio Academy of Science:

The report of the Publications Committee is purely formal. There were no Special Papers published during the year. The Proceedings of the Forty-first Annual Meeting, including the Presidential Address and Authors' Abstracts, were assembled and seen through the press by our efficient Secretary, and published in the July, 1931, number of the OHIO JOURNAL OF SCIENCE, except for the Authors' Abstracts of the Psychology Section which were printed in the November issue of the Journal.

Respectfully submitted,

F. O. GROVER,
Chairman.

Report of Special Committee on Relation of the Ohio Academy of Science to the Ohio Journal of Science.

In the report of this Committee presented at the Annual Meeting of 1931 (and presumably adopted by the Academy, although the Proceedings, p. 220, record the report as "received" and "ordered filed") are the following recommendations:

"The committee recommends to the Ohio Academy of Science:

First. That it is desirable that the Ohio Journal of Science be published and controlled jointly by the Ohio Academy of Science and the Ohio State University.

Second. That the Ohio Academy of Science enter into such a relationship on the following conditions:

1. That the Ohio State University set up an agent that will be legally responsible for the University's interest in the Ohio Journal of Science.

2. That the Ohio State University, or its agent in the matter, agrees to the appointment of a joint Administrative Board for the Ohio Journal of Science. This Board shall consist of four members, two to be appointed by the Ohio Academy of Science from its membership outside the Ohio State University, and two by the Ohio State University or its agent. (Further details of this item omitted. See p. 236.)

3. That it will be mutually agreed by the Ohio Academy of Science and the Ohio State University, that this plan may be terminated on a year's notice by either party.

It further recommends:

That the present special committee on the Academy's Relation to the Ohio Journal of Science, jointly with the Publications Committee of the Academy, be charged with the negotiations with the Ohio State University looking to the adoption of the plan by the University."

On May 20, 1931, the Trustees of the University adopted the following minute, including essentially the substance of the Academy's proposition, although with some minor differences:

"That the interest of the University in the Ohio Journal of Science be reaffirmed, and in order to establish a more definite plan of co-operation with the Ohio Academy of Science in the publication of the Ohio Journal of Science, the following proposals be approved:

1. That the President of the University be designated as the agent of the Board of Trustees in this connection.

2. That such agent be authorized to appoint two members chosen from the science departments of the University, to serve, one for a period of two years and the other for a period of three years, and their successors.

3. That the Ohio Academy of Science designate two persons, not members of the University Faculty, to serve, one for a period of two years and the other for a period of three years, and their successors.

4. That the normal terms of service of such members be three years.

5. That the four members mentioned constitute a joint administrative board.

6. That the duties of such joint administrative board shall be to manage the Ohio Journal of Science under such conditions and terms as such board may establish.

7. That the right to use the name Ohio Journal of Science, the ownership of back numbers of said Journal, and all periodicals received in exchange for said Journal shall be and remain in the University, in case such co-operative plan should be terminated.

8. That the proposed co-operative arrangement may be terminated upon one year's notice by the University or the Ohio Academy of Science.

9. That the University will continue its annual contribution for the publication of the Ohio Journal of Science.

In view of this unexpectedly prompt action by the University, a conference of interested parties was held in Columbus on June 30, 1931. This conference took the following action:

"Subject to immediate ratification by the Special Committee of the Academy on the Relation of the Academy to the Ohio Journal of Science (acting jointly with the Publications Committee) and the Executive Committee of the Academy and to final ratification by the Ohio Academy of Science, the following working plan for the Journal was adopted June 30, 1931, by Herbert Osborn (editor), E. N. Transeau (University member of the administrative board), A. W. Smith (president), C. G. Shatzer (executive committee), W. M. Barrows and F. L. Landacre (present editorial board), and E. L. Rice (chairman, committee on relation of Academy to Journal).

"NOTE.—A parenthetic (U) or (A) following a passage in quotation marks indicates that the quoted passage is taken from previous action of University or Academy, respectively.

"The Ohio Journal of Science shall be published jointly by the Ohio State University and Ohio Academy of Science under a Joint Administrative Board as was recommended by the Academy at its April meeting, and as was voted by the Trustees of Ohio State University in their meeting of May, 1931.

" 'The Joint Administrative Board shall consist of 'four members, two appointed by the Ohio Academy of Science from its membership outside the Ohio State University, on nomination by the Nominating Committee of the Academy, and two by the Ohio State University or its Agent' (A), 'chosen from the science departments of the University' (U).

" 'At the time of the establishment of this Board, one University member and one Academy member shall be appointed for two years, and one each for three years. Thereafter, appointments shall be for term of three years and may be renewed on expiration' (A).

" 'The function of the Joint Administrative Board shall be to determine the larger editorial policies and practices of the Ohio Journal of Science. The Board shall appoint 'the Editor, Business Manager and such Editorial Staff as seems desirable' (A).

" 'The Editor-in-Chief and Business Manager of the Ohio Journal of Science shall participate as non-voting members in the deliberations of the Administrative Board. In the event of a tie vote in the Board, the Editor-in-Chief may cast the deciding vote in all matters except that having to do with appointments to the positions of Editor-in-Chief and Business Manager' (A).

" 'The Administrative Board shall meet at least once a year. Four shall constitute a quorum for transaction of business. In the event of absence of one representative of either party to this agreement, proxy is given by this agreement to his colleague to vote for the absent member on all matters before the Committee' (A).

" 'The Board shall elect its Chairman and Secretary, shall keep records of its actions and transmit a report to the Academy at the Annual Meeting, and to the Agent for the Ohio State University. This report shall record important decisions and shall include the financial statement of the Ohio Journal of Science for the immediately preceding fiscal year of the Journal of Science' (A).

The Academy, annually, shall pay toward the support of the Ohio Journal of Science $1.50 for each of its members in good standing, in return for which the Ohio Journal of Science will be sent to each such member.

" 'The University will continue its annual contribution for the publication of the Ohio Journal of Science' (U).

"All income from sale of copies of the Ohio Journal of Science is to be returned as income to the Ohio Journal of Science; all publications, books and pamphlets, etc., received as exchanges from the Ohio Journal of Science during the period of joint publication are to remain in the Library of Ohio State University.

"The Ohio Journal of Science shall publish the Annual Report of the Ohio Academy of Science as one of its numbers as soon after the Annual Meeting of the Academy as practicable.

" 'This co-operative arrangement may be terminated upon one year's notice by the University or the Ohio Academy of Science' (U, A).

" 'The right to use the name Ohio Journal of Science, the ownership of back numbers of said Journal, and all periodicals received in exchange for said Journal shall be and remain in the University, in case such co-operative plan should be terminated' (U).

"It was further recommended:

1. That the Executive Committee of the Academy be requested to make present appropriation to the Ohio Journal of Science (in addition to the regular $1.50 per member) of an amount sufficient to cover the expense of issuing the Proceedings Number of the Journal or, at least, of an amount equal to the expense of independent publication of the Proceedings by the Academy.
2. That the further determination of the financial policy of the Academy to the Journal be left to the regular meeting of the Academy.
3. That the joint relation of the University and Academy to the Journal appear on the cover of each number and the title page of each volume of the Journal.
4. That an editorial statement of the new administrative policy of the Journal be published in the forthcoming Proceedings Number.
5. That the Editor be authorized to arrange for such additional copies of the Proceedings Number as may seem to him desirable, in consultation with the Secretary, Treasurer, and Librarian of the Academy.

6. That the Executive Committee appoint two temporary representatives of the Academy to serve on the Joint Administrative Board until representatives can be elected by the Academy.

7. That the Proceedings of the Academy be treated as a regular number (or part of a number) of the Journal without special pagination."

The proposed "working plan" was submitted, in above form, by the chairman to the members of the Joint Committee (Special Committee on Relations and Publication Committee) and was approved by E. L. Moseley, J. E. Hyde, F. C. Blake, F. O. Grover, and E. L. Rice. No reply was received from A. P. Mathews. M. L. Reymert had withdrawn from the Academy and his place on the committee had not been filled.

On July 28 the Chairman of the Joint Committee was notified that the Secretary of the Academy had received the approval of a majority of the members of the Executive Committee to the proposed working plan and to the appointment of C. G. Shatzer and E. L. Rice as *ad interim* representatives of the Academy on the Joint Administrative Board of the Journal. (This action was formally confirmed in a meeting of the Executive Committee on December 12, 1931.)

On the basis of these actions, two meetings of the Administrative Board have been held, October 31, 1931, and April 23, 1932, both Academy representatives being present at both meetings. The business of these meetings may be left for the report of the Board.

A meeting of the Joint Committee (Publication Committee and Special Committee on Relations) was held on April 29, 1932. F. C. Blake, F. O. Grover, and E. L. Rice were present; C. H. Otis met with the committee as proxy for E. L. Moseley, and E. L. Rice was authorized to act for J. E. Hyde.

The meeting agreed unanimously to present the following recommendations to the Academy:

1. That the Academy adopt the working plan already tentatively approved by the Joint Committee and the Executive Committee, and that the President and Secretary of the Academy be authorized to sign an agreement with the Agent of the University confirming this action.

2. That the Academy proceed to the election of two members of the Administrative Board of the Journal, one for two years and one for three years, as provided in the working plan.

3. That the question of the further publication of Special Papers by the Academy be left open for further consideration by the Joint Committee (Publication Committee and Special Committee on Relations) and report at the next meeting of the Academy.

4. That, in addition to the $1.50 per member now paid by the Academy to the Journal, the Academy also assume the expense of printing the number of the Journal including the 1932 Proceedings. (In the interpretation of this recommendation it is understood that $1.50 shall be paid to the Journal from each regular membership fee received by the Treasurer, including back dues as well as current. No definite limit was set to the cost of the Proceedings Number; but it is assumed that the Secretary will see that the cost shall not be excessive.)

5. That the Proceedings for 1932 include lists of officers and committees, reports, business transactions, presidential address, and such of the briefer papers or abstracts of longer papers as are placed in the hands of the Secretary at the time of the Annual Meeting. Abstracts to be limited to 300 words.

6. That the copy of the Proceedings be submitted to the Editor of the Journal within one month after the Academy meeting, the Proceedings normally appearing in the first issue of the Journal to go to press after the Academy meeting.

7. That the present Special Committee on Relations be continued for another year, and that the President of the Academy fill the vacancies in the Committee and appoint a member for the new Section of Geography.

8. That the Secretary of the Academy and the Chairman of the Special Committee on Relations be requested to draft such amendments of Constitution and By-Laws as may be necessary, and that this action be construed as notice of such amendments for action at the next meeting of the Academy.

Respectfully submitted,

EDWARD L. RICE,
Chairman.

Report of the Administrative Board of the Ohio Journal of Science.

The "working plan" under which the Administrative Board of the Ohio Journal of Science has been functioning is given in full in the report of the Special Committee on the Relation of the Academy to the Journal, p. 284. Since the approval of this plan by the Executive Committee of the Academy and the Joint Committee, consisting of Publication Committee and Special Committee on Relations, the appointment by the Executive Committee of C. G. Shatzer and E. L. Rice as *ad interim* representatives of the Academy, and the appointment by President Rightmire of F. C. Blake and E. N. Transeau to represent the University, two meetings of the Administrative Board have been held.

At the first meeting, October 31, 1931, F. C. Blake, E. L. Rice and C. G. Shatzer were present of the Board, together with Herbert Osborn, Editor, and B. S. Meyer, Business Manager of the Journal.

The Board organized by the election of E. L Rice as Chairman and B. S. Meyer as Secretary.

It was voted that the calendar year be made the fiscal year of the Journal; and the following staff was elected for 1932:

Editor.......... ....HERBERT OSBORN
Associate Editor........................L. H. SNYDER
Business Manager......................B. S. MEYER

Additional Members of Editorial Staff.

R. V. BANGHAM	E. R. HAYHURST	J. B. PARK
E. LUCY BRAUN	F. A. HITCHCOCK	J. P. PORTER
R. C. BURRELL	G. D. HUBBARD	L. H. TIFFANY
J. E. CARMAN	C. W. JARVIS	F. C. WAITE
A. F. FOERSTE	F. L. LANDACRE	

In the selection of the editorial staff the effort was made to secure representation for a wide variety of subjects and for various parts of the State.

At the second meeting, held April 23, 1932, all members of the Board, the Editor, the Associate Editor, and the Business Manager were present.

A number of detailed recommendations concerning the make-up of the Proceedings Number of the Journal were referred to the Committee

on the Relation of the Academy to the Journal, together with the request that the Academy assume financial responsibility for the cost of this number, in addition to the regular appropriation of $1.50 per member. All of these recommendations were favorably received by the Committee, as shown by its report, p. 284.

The following financial report was presented by the Business Manager and audited by a committee consisting of C. G. Shatzer and E. N. Transeau.

FISCAL YEAR 1931.

RECEIPTS.

Balance from 1930	$ 300 19
Annual University allowance	1,000 00
Dues from Ohio Academy of Science	757 50
Ohio Academy of Science, special payment on "Proceedings"	300.00
Subscriptions	78 00
Authors' payments for plates	71 52
Sale of volumes, back numbers, etc.	21 68
Total Receipts	$2,528 89

EXPENDITURES.

Spahr and Glenn Co., Printing Volume 31	$1,812.00
Spahr and Glenn Co., envelopes	60 00
Bucher Engraving Co.	205.16
James R. Geren, Postmaster	101.70
Labor and clerical assistance.	13 90
Total Expenditures	$2,192 76
Balance on hand at end of fiscal year (Huntington National Bank, Columbus)	336 13
	$2,528 89

It is a pleasure to add, in conclusion, that all actions of the Administrative Board have been unanimous.

Respectfully submitted,

EDWARD L. RICE,
Chairman.

Report of Committee on Junior Scientific Endeavor.

By C. G. SHATZER, Wittenberg College, Chairman.

DELAWARE, OHIO, April 30, 1932.

To the Ohio Academy of Science:

Your committee appointed to promote Junior Scientific Endeavor among high school students has had personal and correspondence contact with a large number of superintendents, high school principals and science instructors during the past year. The results have been exploratory and experimental.

There are in the high schools science clubs under at least thirty names. The departmental clubs in many high schools are not correlating their work, nor are they engaged in co-operative activities. Many of the clubs are accomplishing fine results. The objectives in

many cases are similar to those suggested by the Ohio Academy in its plan for the promotion of Junior Scientific Endeavor. The departments are encouraging students to undertake group and individual projects in scientific fields as part of the activity program.

If the Ohio Academy wishes to stimulate further and better undertakings it must discover methods of encouraging what is being done and avoid conveying any impression to teachers that the objective is to promote further organization. The teachers now consider the high schools over-organized. The Ohio Academy can be of service to the high schools, but to secure results will demand an expenditure of money and time. The members of the Academy must give some of their time and enthusiasm in their own districts.

One satisfactory accomplishment of the committee this year was a district scientific conference of high school students in Springfield. The Urbana, South Charleston, Plattsburg, Yellow Springs, St. Paris and Springfield high schools were invited to participate in this conference. Several of these schools expressed themselves as interested and indicated that they would participate. Finally the departments of Biology, Chemistry and Physics of the Springfield High School presented a well-attended program.

The commendable features of this conference were:

1. The conference was conducted under student leadership with a minimum of teacher guidance.

2. Ninety-four individual and group projects were displayed and a select group demonstrated.

3. Although no announcement of the meeting was sent to the parents and to the general public, a considerable number of adults reviewed the projects and attended the demonstrations.

4. Fifty-five students were present.

The committee recommends that:

(1) The Academy's project be referred to the Executive Committee for review with power to act. The present committee is convinced that the project has merit and that the basic work done should not be lost.

It is further recommended that:

(2) The Executive Committee should be given authority to appropriate for the work a sum of money that it deems adequate to accomplish results.

Respectfully submitted,

THE COMMITTEE,

C. G. SHATZER,

Chairman.

Action by the Academy.

Upon the conclusion of the reading of the above report, the following motion was unanimously passed:

That the report be accepted with thanks to the committee, that the committee be discharged and that the recommendations contained in the report be referred to the Executive Committee with power.

Report of the Committee on State Parks and Conservation.

DELAWARE, OHIO, April 30, 1932.

To the Ohio Academy of Science:

At first thought one might consider that a report on Conservation activities might be a trifle out of place under present economic conditions, but a more deliberate survey will, we think, disclose a greater reason for careful attention to such matters. In time of stress such as we have been passing through there is all the greater need of deliberate thought on measures of conservation and plans for healthful opportunities in recreation. Therefore no apology is made for making this report cover not only items of progress but also suggestions for further effort. Even a dry committee report may serve as a slight diversion from economic cares.

It may be recalled that the subject of Conservation is not a new subject for the Academy. At the meeting held at Denison University in 1908 a program of several papers on different phases of the subject was submitted and a set of resolutions adopted which it may be appropriate to repeat here.

"The Ohio Academy of Science at its session in Granville, November 27 and 28, 1908, after a special program devoted to the discussion of the conservation of the natural resources of the state, adopted the following resolutions as expressing its position in regard to the importance and necessity of active measures for state conservation:

Resolved, That it is the desire of this Academy to place itself on record as favoring active efforts in support of the movement for rational protection of the resources of the country; that we cordially indorse the movement that has resulted in the formation of a National Conservation Commission, and urge the extension of its powers that it may direct the movement to a practical end.

We recognize the need in Ohio for action in the conservation of coal, and urge that measures providing for national control be enacted where state supervision is impracticable. We urge the importance of forest conservation and extension as a vital necessity for the future welfare of the state, and the formation of a forestry commission or establishment of a state forest service at the earliest possible time.

We recognize the necessity of immediate attention to the waterways and measures to conserve and utilize the possibilities for power, irrigation and navigation in the water areas, and of a scientific investigation of the biological resources connected with aquatic life, and urge the passage of a bill to establish a Biological Survey.

We would urge the formation by the Governor or General Assembly of a State Conservation Commission, at least one-half the members to be men of scientific training, to consider and report to the Government on important measures for conservation.

We recommend a Committee on Conservation in the Academy, and the arrangement for our next annual meeting of a special session devoted to a discussion of the questions pertaining to the conservation of the resources of the State."

It will be noted that some of the measures advocated at that time have been put in force, notably in the line of state forests and game refugees and also in the starting of the Ohio Biological Survey and the establishment of the State Division of Conservation. As it stands we do not have as yet a Conservation Commission one half of whose members are men of scientific training. However, we believe there have been sincere efforts to inaugurate desirable plans and we note with

satisfaction that the recently appointed Commissioner of Conservation is making a sincere attempt to do constructive work. The Commission has established in the line of game propagation a twenty-five acre raccoon ranch at Milan, Ohio, a 271 acre Cotton-tail Rabbit ranch at Milan, Ohio, and Propagation of Hungarian partridge and Ruffled grouse at the Urbana Game Farm.

For fish propagation, improved technique in hatching and rearing, including fertilization of ponds to increase production of entomostraca, spawning boxes for small-mouth black bass; keeping hatchery records and weighing fingerling fish before they are planted in order to accurately determine hatchery production.

The policy in stocking, planting only suitable species of fish in their natural habitats in closed streams where they will have a chance to spawn and their young to develop without being molested. Stocking according to habitat is also being applied to the distribution of ring-neck pheasants, Hungarian partridges and other species of game.

In the line of education and research they offer weekly radio talks; quail investigation; stream and lake surveys; publication of the following booklets: "Some Food and Game Fishes of Ohio" and "Ohio Game and Song Birds in Winter." And in fish and game protection, education of fish and game protectors in the broader aspects of Conservation.

The "Save Outdoor Ohio" Council has been promoting particularly the project of Bridge-Dams ably advocated by our Academy member, Mr. J. C. Goodman, and this plan has been taken up by the Division of Conservation, the Highway Department and the Water Conservation Board with a view to building some half dozen of these bridge-dams as trials in locations to be selected by the Water Conservation Board. The next step in this project is to have passed some very simple legislation that will make it possible to build these bridge-dams along county, municipal or state highways, wherever conditions seem to warrant it. The Council has also been giving much attention to the matter of promoting roadside beauty and it has under consideration legislation to regulate billboards and other interferances to roadside beauty.

The Wild Flower Preservation Society Ohio Chapter is undertaking an educational program, the aim being to put before the people of the state information as to what conservation really is and what it includes. The plan is to print copy for general distribution and it may be noted that a program of education including the importance of wild flower preservation is in progress by the Central Ohio Anglers' and Hunters' Club. Their entire program, however, includes conservation measures of still wider scope and a resolution adopted unanimously by the Club is worthy of inclusion here:

"WHEREAS, the season of wild field-flowers, ferns, shrubs and flowering trees is about to open, spreading the beauties and fragrance of Nature abroad for all people to enjoy; and

WHEREAS, vandalism is rapidly depleting all these beautiful things threatening their extinction, if it be continued, ere many years; therefore, be it, by the Central Ohio Anglers' and Hunters' Club,

Resolved, That this Club expresses its disapproval of and opposition to all forms of such vandalism; urges all persons to refrain from picking, removing or

damaging such wild field-flowers, ferns, shrubs and flowering trees, and requests the newspapers of Columbus and Ohio to publish this Preamble and Resolution, and to use it as a text for a concerted and persistent campaign for the general protection of such forms of wild life."

It is certainly encouraging that so many different organizations are becoming interested in phases of conservation and it is certainly desirable that we should endeavor to assist in directing these efforts in the most favorable channels. The establishment of a Water Conservation Board on which our Academy member, Mr. David C. Warner, is the Executive Secretary, inaugurates a comprehensive survey of the water resources of the state and this detailed program marked out by Mr. Warner should certainly result in some valuable advances toward measures for conserving and utilizing our aquatic resources.

We commend the Ohio State Forestry Department, under the leadership of Mr. Secrest, for the efficient manner in which the State Forests are being managed, making them available and usable for large numbers of citizens and visitors from other states. We regard these forests and parks as splendid object-lessons for our citizens in the principles of conservation.

While we are heartily in favor of making many of our State Parks and Forests accessible and available to the maximum number of citizens, we also regard it important that a number of choice situations be allowed to remain as inaccessible as possible and in as undisturbed condition as may be practicable for the use and study by students of ecology and other allied sciences. Such places should be regarded as sanctuaries for the preservation of such of our flora and fauna which are unable to survive under conditions which are likely to obtain when large numbers of people visit and wander about over the grounds of a state park. We recommend, among other sites of this sort, Conkle's Hollow, because of its relative inaccessibility at present and because of its comparative wealth of flora and fauna.

The discussion of geology by Dr. Ver Steeg of the geological features of the state parks will certainly be of much interest and it is hoped that he will complete a series covering at least the more important of the present state parks.

Recommendations.

We recommend the enactment of suitable legislation to protect our vanishing species of wild flowers and to protect the owners of lands adjacent to public highways from vandalism. Unless such legislation is soon enacted, lands adjacent to heavily traveled highways more recently opened to traffic will be stripped of their more attractive flowers and shrubs, just as the highways which have been improved for a greater length of time are already barren and despoiled of roadside flowers and shrubbery. Persons selling trees or shrubs taken from farms or forests might be required to have a license as required from nurserymen.

We favor legislation to increase the area of State Parks and Game Refugees as rapidly as they can be acquired and properly cared for.

We recommend that officers of the Conservation Committee be urged to set apart certain suitable areas as wild life refugees or sanctuaries within which all forms of native plants and animals may be left undisturbed, and that such places be not open to the public or provided with roads or public paths, but made available under proper restrictions for scientific observation by biological investigators duly authorized by proper authorities in charge.

We recommend that a careful study of the Roosevelt Game Reservation be made to determine the conditions favorable to permanent preservation of the native wild life of the state and that any introductions be limited to plants and animals native to this region to the end that this important refuge may serve as an outstanding feature in conservation particularly with reference to the perpetuation of the native game animals of Ohio.

We believe that all persons interested in conservation of our wild life should rally to the support of our birds of prey. Due to popular prejudice resulting in indiscriminate persecution of all species, our birds of prey are rapidly decreasing in numbers, some species being threatened with extermination. The great majority of our predacious species have long since been proven to be beneficial in their food-habits, while the few species known to be more or less destructive are so reduced in numbers that any damage attributable to them is negligible.

We recommend that all birds of prey be protected by law, subject to the right of any citizen to control them when in the act of destroying his property.

We further believe that the pole-trap is a wasteful and inhuman means of capturing birds of prey, since it not only does not discriminate between injurious and beneficial species of predacious birds, but also destroys large numbers of song-birds and game mammals. We therefore recommend that legislation be enacted making use of the pole-trap illegal.

The following areas are suggested for state park reserves:

1. Parts of Liberty Township, Jackson County. Here the Sharon conglomerate is a massive stratum from 50 to 200 feet in thickness and through weathering and erosion has been carved into deep narrow valleys or gorges. These offer fine scenery, have a selected flora and fauna, with southern affinities, and are easy of access. At present there is an attempt being made to have the State take over Rock Run. Such a move should be encouraged. Other parts worthy of preservation are Ophir Falls, White's Gulch, Vance Rock, and Big Rock.

2. Sunfish Valley in Monroe County. Stands out as one of the finest in the State. Here the relief is more than 600 feet, the valley narrow, and the walls steep and rugged. The Waynesburg sandstone outcropping about 300 feet from the valley floor causes many fine cliffs, sharp constricted valleys, and favorable places for selected plant and animal life. The best part of the valley is that between Cameron and Coats Station.

3. The Valley of Little Beaver Creek between Smith's Ferry on the Ohio River and Saint Clair or Fredericktown at the junction of North

Fork and Little Beaver Creek, eastern Columbiana County, is a narrow rugged gorge of recent origin. The stream is rock bound and has little or no flood plain. It is well worthy of preservation for its many natural features.

4. Since the abandonment of the interurban railroad, the Black Hand gorge on the Licking River east of Newark may be acquired for a small outlay. It is of interest for its scenery, life features, and geological history.

5. Brush Creek in Adams County offers much to the botanist and geologist as well as to those seeking scenery alone.

6. Luke Chute on the Muskingum River is one of the most beautiful spots in the State and should be preserved.

HERBERT OSBORN, *Chairman*	E. LUCY BRAUN,
E. L. WICKLIFF,	E. R. HAYHURST,
E. S. THOMAS,	WILBUR STOUT,
ROSCOE FRANK,	EDMUND SECREST,

Committee.

Action by the Academy.

The above report together with all accompanying Resolutions and Recommendations was, upon motion duly made and carried, accepted, approved and ordered filed.

NOTE: After the meeting the following letter was received from Mr. Secrest, who had been away at time the draft of report was sent to him:

"I have read the proposed report of the Committee on Conservation and State Parks and am glad to give it my approval.

As you know, funds for purchase of state forests and forest parks were not forthcoming at the last session of the Legislature, so we are doing nothing along this line excepting some clean-up purchases. The area of state forests and forest parks now total nearly 60,000 acres. From funds appropriated during the last biennium we have the past year added 12,786 acres of land to the state forest and forest park system. One more state forest unit was added—that of Zaleski Forest in Vinton County, of 3,393 acres. This contains some of the best first growth forest in the system.

I believe you and I have discussed the advisability of isolating choice sites that were to remain absolutely in their native condition, and to be inaccessible for promiscuous visiting. With this I am in hearty accord. For this purpose we have already set aside what is known as Little Rocky Branch in Hocking County, an area of about 300 acres. There are also portions of Shawnee Forest in Scioto and Adams Counties, and the Scioto Trail Forest in Ross County that could be set aside for this purpose. Springer Hollow in Hocking County could also be included. I think it might be well for the Conservation Committee of the Academy to establish a policy for these lands to be so set aside for their biologic interest. I think you will find that a number of areas now owned might be used for the purpose in mind. I am thinking of portions of the 3½ mile gorge connecting Old Man's Cave with Cedar Falls. Even though there is a trail through the gorge, there are lateral ravines that are never visited.

EDMUND SECREST."

Report of the Committee on Necrology.

To the Ohio Academy of Science:

The Committee on Necrology has submitted to the Secretary the following report:

Dr. A. B. Plowman.

This year saw the passing of Dr. A. B. Plowman, Professor of Biology at the University of Akron, a man long working in Ohio biological circles. He died January 3, 1932, after a lingering illness.

Amon Benton Plowman was born in Ohio, at the little town of Greenville, May 14, 1873, reared there, and at Ohio Wesleyan Academy and University, from which he graduated in 1899, with the degree of B. S. A broad interest in science and high scholarship, attested to by his part-time teaching in both physics and biology in these early days, led him to graduate work, which he did at Harvard. An intention to enter upon medical work was superseded by a growing interest in biology for its own sake. He majored in botany, taking the M. A. and then the Ph. D., completing the latter in 1905.

He taught at Harvard, and then at smaller colleges, spending some years as Professor of Biology at Carroll College, Wisconsin, after which he came to Akron, in 1915. Here in the old Buchtel College, then but recently made the nucleus of a municipal university, the department grew rapidly under his direction, both in students and in staff.

His technical training in botany, especially plant morphology, culminating in his Ph. D. dissertation and in other papers on Cyperaceae and Juncaceae, did not lead to later work in such lines. With his interest in all things biological, he developed more and more certain zoological interests, particularly in the various aspects of human biology. He was much concerned with biology in its relation to human welfare, and in public health measures. His favorite course, "Human Biology," presented material valuable personally, to great numbers of students. He taught a course in physiology, and at times genetics, and others, as well as formerly the general biology course. An outstanding feature of his teaching was a fluent but measured lecture presentation that always evoked attention.

Dr. Plowman was a member of the Ohio Academy since 1915, a fellow since 1920, and also Vice-President of the Botanical Section in 1920. He was a fellow of the A. A. A. S., a member of the Botanical Society of America, American Public Health Association, and others. He was also a member of Phi Beta Kappa, and Phi Sigma.

Dr. Plowman enjoyed a long, happy marriage. He retained throughout life an abiding interest in religion that meant much to him, and which was unobtrusively merged with his deep interest in science, in what was evidently a fine personal philosophy.

His characteristics of modesty, dignity, simplicity, kindliness in all his relations are richly remembered by his colleagues and friends.

Walter C. Kraatz.

Dr. R. A. Slagg.

In the death of Dr. Rodney A. Slagg, a member of the Ohio Academy since 1928, there occurred the death so lamentable, of a man still in his thirties, destined to do much and make much out of life.

Rodney Arthur Slagg was born at Fort Atkinson, Wisconsin, September 9, 1894. From his home town, he went to the Whitewater, Wisconsin, State Normal School for his training and first collegiate work. He taught biology in high schools, and then interrupted his career to serve in the World War. After his return, he resumed his teaching and studies. At the University of Wisconsin he took his B. S. in botany in 1923, and his M. S. in 1924. He taught at the Madison High School, and assisted in botany at the University while he started on his Ph. D. work.

In 1927 he came to the University of Akron as Assistant Professor of botany, and also gave a course in geology. His energy, enthusiasm, ability, and teaching qualities were soon recognized. On a leave of absence for the school year 1929–1930, he completed his Ph. D. work in botany at the University of Wisconsin in the summer of 1930. Another year of teaching was completed at Akron, and the following summer while again working at his favorite haunts in Madison, he died following an operation, August 6, 1931.

Dr. Slagg's dissertation was "The Gametophytes of Selaginella Kraussiana, I, The Microgametophyte," published in the *American Journal of Botany*, XIX, pp. 106–126, February, 1932.

He was a member of Phi Beta Kappa, Phi Sigma, Botanical Society of America, and the Ohio Academy. Dr. Slagg was not married.

Walter C. Kraatz.

Maximilian Braam.

(Prepared by L. Smith.)

Maximilian Braam, retired teacher of biology at Hughes High School, died suddenly at his home, 3449 Lyleburn Place, Cincinnati, October 11, 1931. He collapsed from an apoplectic stroke and died before a physician could be summoned.

Mr. Braam was born in Holland, September 8, 1850. After studying there and serving in the Dutch Army, he came to Cincinnati. Here he taught school for over 35 years. His first school was at North Bend and from there, in 1889, he went to the Third Intermediate School, at Cincinnati, in 1898 to the McKinley, where he was principal, and in October, 1904, to Hughes High School, where he taught biology. He retired in June, 1921, at seventy years of age.

While teaching school he became a student at the University of Cincinnati, where he continued his studies for over thirty years, sometimes as a day student and sometimes as an evening student. He received his Bachelor of Arts degree in 1906 and in 1914 the Master of Arts degree. He had completed practically all of the requirements for the Degree of Doctor of Philosophy and was preparing a dissertation on the Dialects of Zeeland as his doctor's thesis. In 1926 and 1929 he visited the Zeeland region of Holland and gathered material for his

paper. He had hoped to make another trip to the region before completing his thesis.

Mr. Braam was a teacher of biology for seventeen years and that field may be said to have had a major claim on his interests. But he did not exclude other lines of study. He was an enthusiastic student of Sanskrit and of the Old Norse and Icelandic languages. He spoke fluently not only in English and Dutch, the latter his native language, but also in German and French. He also spoke Italian and Spanish.

His scientific interests included astronomy, chemistry, botany and geology. He devoted some time to microscopic studies of plant and bacterial life. He was an ardent lover of poetry and some of his own contributions were published in the "School Index." Many of his former students recall with pleasure his custom of prefacing his lectures in biology with choice lines of poetry, some of which were the product of his own pen. Some of his former zoology students remember too his method of dramatizing elements in the life history of various species and retain indelible impressions as the result of his consummate technique.

Mr. Braam was secretary of the Ohio Botanic Garden Society and had been active in its efforts to develop a Botanic Garden at Cincinnati. He was a member of the Cincinnati Schoolmasters Club and of the Alliance Francaise.

WALTER H. BUCHER,
Member Necrology Committee.

Report of the Committee on the Election of Fellows.

DELAWARE, OHIO, April 29, 1932.

To the Ohio Academy of Science:

The Committee on the Election of Fellows met last evening in the Alumni Parlor, Edgar Hall, Ohio Wesleyan University, Delaware, Ohio, with ten members present and two absent (C. G. Shatzer and F. G. Tucker). The following members whose nominations were in proper form and accompanied by satisfactory documentary evidence of the nominee's scientific achievements, received the required three-fourths vote of the committee and were declared duly elected to Fellowship in the Academy, viz.:

S. PRENTISS BALDWIN
HOMER G. BISHOP
ALBERT FRANKLIN BURGESS
HARRY F. DIETZ
WINSTON F. DUNHAM
HAROLD A. EDGERTON
LINDEN F. EDWARDS
RAY LEE EDWARDS
ROBERT M. GEIST
LOUIS DUNTON HARTSON
ROBERT A. HEFNER
NEALE F. HOWARD
RALPH A. KNOUFF
CHESTER O. MATHEWS
FRANCIS NORTON MAXFIELD
ZENO PAYNE METCALF
CLAUDE R. NEISWANDER
JAMES RUEY PATRICK
SIDNEY L. PRESSEY
JOHN WORTHINGTON PRICE
J. P. SLEESMAN
GUY HAROLD SMITH
ISABEL SEYMOUR SMITH
LAURENCE H. SNYDER
AUGUST W. TRETTIEN
RICHARD STEPHEN UHRBROCK
WILLARD L. VALENTINE
EUGENE VAN CLEEF
GEORGE W. WHITE

Report of the Membership Committee.

DELAWARE, OHIO, April 30, 1932.

To the Ohio Academy of Science:

Your Committee on Membership submits the following applications in due form and recommends the election of the applicants to membership in the Academy:

BARTLETT, GERTRUDE, Dayton. *Botany.*
BEAM, J. ALBERT, Tiffin.
BEMISDERFER, F R., Cleveland. *Chemistry.*
BONTRAGER, W. E., Oberlin. *Botany.*
BROWN, CLARENCE M., Columbus. *Pharmacy.*
CAIN, ADA DORRIS, New Concord. *Botany.*
CAIN, DR. STANLEY A., Bloomington, Ind. *Botany.*
CLARK, ROBT. L., Bartlett. *Entomology.*
CLIPPINGER, D. R., Athens. *Chemistry.*
CLIPPINGER, F. E., Dayton. *Botany.*
COLE, ARTHUR C., JR., Columbus. *Entomology.*
COLES, CLIFFORD H., Westfield, N. J. *Botany.*
DARLING, FRED S., Columbus. *Physical Sciences.*
DAVIDSON, RALPH H., Columbus. *Entomology.*
DREYER, WILLIAM A., Cincinnati. *Zoology.*
FORD, E. N., Wooster. *Physics.*
FRASURE, N. W., Basil. *Botany.*
FREEDMAN, M. A , Columbus. *Zoology.*
FREY, CARL A., Athens. *Medical Sciences.*
GARLAND, JOHN H., Columbus. *Geography.*
HANEY, JEAN WHITE, Columbus. *Botany.*
HAUB, JAMES G., Columbus. *Zoology.*
JANSON, EVA ELLEN, Columbus. *Biology.*
KEHOE, ROBERT A., Cincinnati. *Physiology.*
KERNHOLTZ, D. L., Columbus. *Botany.*
KING, DOROTHY D., Columbus. *Psychology.*
KIRK, W. J., Steubenville. *Physical Therapy.*
LANG, ALPHONSE, Cincinnati. *Biology.*
LIMING, FRANKLIN G., Columbus. *Botany.*
LUCAS, H. C., Columbus.
MADISON, WILLIAM JAMES, Wilberforce. *Physiology.*
MANUEL, WILLIAM A., Delaware. *Chemistry.*
MASON, PAUL, Columbus. *Botany.*
MELVIN, JOHN H., Chillicothe. *Geology.*
MOTOK, GEORGE THOMAS, Columbus. *Physical Sciences.*
OWEN, PROF. G. E., Yellow Springs. *Physical Sciences.*
PARRIS, FRANK G., Columbus. *Geology.*
PATCH, LAWRENCE H., Sandusky. *Entomology.*
PETERSON, VINCENT R., Cleveland. *Botany.*
PRICE, ERNESTINE, Columbus. *Botany.*
PYRTLE, RALPH N., Wilberforce. *Zoology.*
RIGG, MELVIN, Gambier. *Psychology.*
RISTOW, WALTER W., Oberlin. *Geography.*
SANDEFUR, B. T., Oxford. *Geology.*
SCHWARZ, HERBERT E., Columbus. *Medical Sciences.*
SCRANTON, ROBERT, Alliance. *Geology.*
SHARP, WINFORD L., Wooster. *Psychology.*
SHURRAGER, P. SHERIDAN, Athens. *Zoology.*
SMITH, LEON E., Granville. *Physics.*
STEVENS, MISS MARGARET E., Oberlin. *Geography.*
SUPER, CHARLES W., Athens. *Psychology.*
TURNER, J. J., Hiram. *Botany.*
WATSON, ALFRED N., Columbus. *Botany.*

WEISHAUPT, CLARA, Columbus. *Botany.*
WERDELMANN, WILHELMINE, Columbus. *Medical Sciences.*
WHITEFORD, CHARLOTTE, New Philadelphia. *Botany.*
WOLFE, JOHN N., Columbus. *Botany.*
YOUNG, IRVIN F., Columbus. *Botany.*

Respectfully submitted,
GEORGE D. HUBBARD, *Chairman*,
A. C. CONGER.

Report of the Committee on Resolutions.

DELAWARE, OHIO, April 30, 1932.

To the Ohio Academy of Science:

The Committee on Resolutions begs leave to offer the following resolutions:

The Ohio Academy of Science expresses its appreciation of the courtesies extended by the authorities of Delaware and the committees of Ohio Wesleyan University, and especially to the Chairman of the Local Executive Committee, Professor C. E. O'Neal, and to the management of Stuyvesant Hall for the splendid dinner served last evening.

We also heartily endorse the recommendations and resolutions presented by the Committee on State Parks and Conservation.

We further recommend that the Secretary express our appreciation to those concerned and inscribe these resolutions as a part of the minutes of this meeting.

E. LUCY BRAUN,
E. H. JOHNSON,
Committee.

Report of the Nominating Committee.

DELAWARE, OHIO, April 30, 1932.

To the Ohio Academy of Science:

Your Committee on Nominations has the honor to submit the following report:

President—R. A. BUDDINGTON.

Vice-Presidents:
A. *Zoology*—W. C. KRAATZ.
B. *Botany*—BERNARD S. MEYER.
C. *Geology*—CARL VER STEEG.
D. *Medical Sciences*—F. A. HITCHCOCK.
E. *Psychology*—L. D. HARTSON.
F. *Physical Sciences*—A. A. ATKINSON.
G. *Geography*—G. D. HUBBARD.

Secretary—WILLIAM H. ALEXANDER.

Treasurer—A. E. WALLER.

Elective Members, Executive Committee—ALPHEUS W. SMITH AND M. E. STICKNEY.

Trustee, Research Fund—HERBERT OSBORN.

Publications Committee—F. O. GROVER, FREDERICK C. BLAKE AND E. L. MOSELEY.

Library Committee—F. O. GROVER.

Committee on State Parks and Conservation—J. ERNEST CARMAN, E. L. WICKLIFF AND ROSCOE W. FRANKS.

Joint Administrative Board, Ohio Journal of Science:
For 3-year term—E. L. Rice.
For 2-year term—C. G. Shatzer.

Respectfully submitted,

Wencel J. Kostir, *Chairman*,
Eugene Van Cleef,
James P. Porter,
Frank J. Wright.

THE SCIENTIFIC SESSIONS.

General and Sectional.

The following is a complete list of the addresses and papers presented at the various general and sectional meetings of the Academy as reported to the Secretary:

The Dutch elm disease in Ohio .... O. N. Liming
Description of an instrument for the accurate quantitative determination of cholorophyll.......... R. E. Oltman
Motion Pictures: The treatment of osteomyelitis with blowfly larvae, D. F. Miller, C. A. Doan, E. H. Wilson
Presidential Address: Physics and Human Experience.....Alpheus W. Smith
Supplemental Records and Notes for Ohio Leafhoppers......... Herbert Osborn
Temperature and the heart beat in Caddis Fly Larvae .. ... .Henry Federighi
Ecology of Ohio Band-winged Grasshoppers (Orthoptera; Acrididae; Oedipodinae).......... E. S. Thomas
A Preliminary Report on Mallophaga infesting Cowbirds.....Robert M. Geist
Observations on a clone culture of Amoeba bigemma ....John C. Lotze
Protozoa of the alimentary tract of the wood-eating roach....... J. A. Herrick
Breeding Hermit Thrushes feed migrating salamanders to nestlings during drought.......... Louis B. Kalter
Observations on the nesting of the Black Throated Green Warbler, Margaret M. Nice
A Preliminary Report of the Food Habits of Barn Owls at Ohio Wesleyan University.......... Arthur Stupka
Winter Feeding of Game Birds.......... Lawrence E. Hicks
Tagging of Fish in Ohio .... Ralph V. Bangham
Insect Food Studies of some Lake Erie Fishes.......... M. W. Boesel
Controlling temperature in laboratory experiments: Types of apparatus used, Craig W. Eagleson
Effect of certain Weather Conditions on Flight of Nocturnal Insects as Reflected by Light Trap Catches.......... W. C. Stehr
A Study of Avicularia avicularia, the large spider often brought here in bunches of bananas .... R. L. Baird
The Effect of Salts in the Hydrogen Ion Concentration on the length of life in Asellus sp .... Emmett Rowles and P. S. Shurrager
Discussion of Responses to Electrical Stimulation in the Leech. John A. Miller
The Origin of the Naiad Fauna of the Great Lakes Region...... H. R. Eggleston
Growth in Daphnia magna .... G. Anderson
Notes on Macrobrachium ohionis (large fresh-water shrimp), Robert N. McCormick
Growth studies of certain fishes in Buckeye Lake .... Wilbur W. Grimm
Food Habits of some Ohio Raptorial Birds .... Arthur Stupka
The Fresh Water Medudae of Vermillion River .... R. L. Baird
A Cytological Study of the Glandular Epithelium of Lumbricus, Thurlo B. Thomas

The Effects of Various Foods upon the Metamorphosis of Blowflies .J. G. HAUB
A Study of Fertility in the Blowfly (Phormia regina). FRANK COWAN
The Reactions of certain Cladocera to Colored Lights of Equal Intensity, HYMEN LUMER
The study of living marine animals at inland laboratories . . W. J. KOSTIR
The Inheritance of Various Taste Deficiencies in Man . . .LAURENCE H. SNYDER
The Phaenogenetics of Drosophila funebris . . . . WARREN P. SPENCER
The Effect of Strychnine Sulphate on the Melanophores of Eupomotis gibbosus, GEORGE RUGGY
Encrangonyx mucronatus Forbes, a blind subterranean shrimp reported from Ohio . . . . STEPHEN R. WILLIAMS
Notes on a few interesting Florida Plants .. . ... H. C. BEARDSLEE
Some Natural Color Photographs of Wild Flowers .. . .R. A. DOBBINS
The Living Cell and the Mechanism of Photosynthesis . ... O. L. INMAN
Stomatal Investigations on Young, Mature, and Senescent Leaves, GLENN W. BLADES
Starch Synthesis in the Variegated Leaves of Pelargonium, A. G. CHAPMAN AND W. H. CAMP
Length of Water Conducting Vessels in the Elm Stem. .. .. F. G. LIMING
The Water Deficit of an Extreme Xerophyte.... .. ..ERNEST H. RUNYON
Sectioning Woody Stems with Use of Steam.. , ...ARTHUR T. EVANS
The Structure of the Flowers of Hemp.. .... W. H. CAMP
Orthogenic Evolution of the Degree of Divergence between Carpal and Foliar Leaves. .. ..JOHN H. SCHAFFNER
The Forests of the Illinois Drift Plains of Southwestern Ohio . . .E. LUCY BRAUN
Xenia and Ectogeny versus Meta-xenia. .... .A. E. WALLER
The Vegetation of Logan County, Ohio. ....OLIVER D. DILLER
Developing New Dusts for the Control of Apple Scab, A. E. PIERSTORFF AND H. C. YOUNG
Grain Rusts in Ohio During 1931 . . ..W. G. STOVER AND C. W. HORTON
The effect of ultra-violet light of various wavelengths on pigmentation and growth of bean seedlings .. .. .R. E. OLTMAN
Stolons of the Trepostomata ....GEORGE B. TWITCHELL
Recent Discoveries in Early Paleozoic Strata in Northeastern China, Manchuria and Korea. ....AUGUST F. FOERSTE
A possible pseudobornia from the Ohio Shale . ... .WILLARD BERRY
Base Saturation as an Indication of the Extent of Leaching of Surficial Materials.............. .... G. W. CONREY
Plans for the Annual Spring Field Trip.. ....EDMUND M. SPIEKER
Salient Features of the Appalachian Valley in Virginia....... . ARTHUR BEVAN
Pre-Cambrian Geology in Central Virginia .. .. A. S FURCRON
A Bone-bed in the Delaware Limestone... LEWIS G. WESTGATE AND R. P. FISCHER
Some Ordovician Correlations in Southern Kentucky . . ... W. H. SHIDELER
Explanation of Certain Abnormal Sedimentation Behavior of Clay, HAROLD G. CASSIDY
Solution Phenomena in the Basal Oneota Dolomite ... .WM. A. P. GRAHAM
Glacial Limestone Deposits near Mt. Liberty, Ohio . .... . RICHARD C. LORD
Pre-Cambrian in Ohio ....GEORGE D. HUBBARD
Network Passages and the Origin of Limestone Caverns . . .A. C. SWINNERTON
The Caves of Yarim Burgaz, Turkey..... ... . .GEORGE D. HUBBARD
Some Features of the Drainage History of the Upper Ohio..... . .G. F. LAMB
Drainage Changes of the Upper Mahoning River, ROBERT SCRANTON AND G. F. LAMB
Gasoline Pollution by Underground Water . ... KARL VER STEEG
Cross Warping in the Acadian Appalachians .... H. DAYTON SQUIRES
The Treatment of Tularemia with a Specific Antiserum . . . . LEE FOSHAY
The Effect of Various Stimuli on the Basal Metabolic Rate, the Blood Pressure, and the Galvanic Reflex in Man. . ... E. ROWLES AND J. P. PATRICK
Child Labor in the United States as Subjected to Poisons and Dusts, EMERY R. HAYHURST
Data on Ventilation Conditions—A Field Neglected by the Physicians, EMERY R. HAYHURST

The Ultra Violet Absorption Spectra of Vitamin B Concentrates as Correlated with their Potencies .. . FRANCIS F HEYROTH AND J. R. LOOFBOUROW
The Effects of Small Amounts of Ethyl Alcohol on the Respiratory Exchanges During Rest, Work and Recovery ROBERT C. GRUBBS AND F. A. HITCHCOCK
Vaccine in the Prevention of the Common Cold . W. E. BROWN
The Metabolism of a Woman 106 Years Old, J R MATSON AND F. A. HITCHCOCK
The Acceleration of the Ulcer Producing Action of Bile Salts . ..L. H. SCHMIDT
The Central Connections of the Eighth Cranial Nerve in the Guinea Pig, RUSH ELLIOTT
Decomposition Products of Chlorophyll in a Herbivorous Animal and the Relationship of these Products to Haemin ... . PAUL ROTHEMUND
Teaching Scientific Methods in Health Education . MRS. NORMA SELBERT
A Chemical Study of the Blood in Quiet and Excited Rabbits.. .. H. L. KATZ
Some Observations on the Relation of Bodily Weight to the Mental Status in Schizophrenia (Dementia Praecox) . . . .CARL SAWYER
Hematoporphryn, an Artificial Proteolytic Enzyme . . . . M. J. BOYD
The Ingestion and Excretion of Lead in Primitive Life.. . .. ROBERT A. KEHOE
A Physiological Mechanism in Control of Blood Coagulability . .DON D. IRISH
Sodium Ricinoleate in the Detoxification of Bacterial Antigens, STANLEY E. DORST
On the Chemistry of the Hinton Test for Syphilis:
(1) Nature of the Muscle "Antigen".. . .. . SHIRO TASHIRO
(2) A Synthetic "Antigen".. .. .. MISS C. M. VACK
The Energy Cost of Muscular Exercise. . . . HOWARD E. HAMLIN
(Professor Hamlin will also give a demonstration of a new simplified Sphygmograph recently invented by himself and Professor Hindman.)
Report of a Malignant Sacro-Coccygeal Chordoma, VERNE A. DODD, HARRY L. REINHART AND RALPH A. KNOUFF
The Development of Funtionally Specific Ectodermal Placodes in Rana Pipiens .. .. RALPH A. KNOUFF
Data on the Problem of the Descent of the Testis...... ..... L. C. GERLINGER
The Behavior and Autopsy Findings in a Case of Cerebellar Agenesis in a Dog .. ..GRANT O. GRAVES
The Neurological Findings in a Case of Cerebellar Agenesis in a Dog, F. L. LANDACRE
An Apparatus for Studying the Reactions of Newborn Infants to External, Thermal Stimuli . . . .W. J. CAMERON
A Case of Microcephaly believed to be due to Roentgen Irradiation During Foetal Life. (Demonstration of the patient, slides, and discussion), FRANCIS N. MAXFIELD
Physical Health and Psychological Adjustments in Children..A. SOPHIE ROGERS
A Method for Measuring Changes in Attitude Resulting from a Radio Talk, F. H. LUMLEY
Emotional Status of Parents of Problem and Psychopathic Children, EDNA R. LOTZ
Changing Relationships of Ability and Scholarships Measured During Four Years of University Study .. ..W. C. HALSTEAD
A Study of Senescence ....K. SWARD
An Experimental Study of Persistency, JAMES P. PORTER AND LEONARD L. HENNINGER
Learning of Mechanical Puzzles by White Rats. (Motion picture demonstration). . . . . H. HANSON
An Experimental Comparison of Psychophysical Methods.. .J. P. CURTZDAFNER
The Program of the Ohio Mental Hygiene Association..........C. S. SHERWOOD
The Relation between Length and Difficulty in Motor Learning; a Comparison with Verbal Learning. .THURMAN C. SCOTT AND L. L. HENNINGER
The Work of the Bureau of Examination and Classification, Columbus State Penitentiary.......... ....G. R. MURSELL
Psycho-genesis .. . . ROGER BELLOWS
Why do College Students Differ in Moral Attitude and Religious Beliefs: A Statistical Study.... ....C. W. GLEASON

Final Revision of the Crystal Structures Present in Certain Chromium-nickel Alloys. ....J. O. LORD AND F. C. BLAKE
An Exact Determination of the Ratio of the Edges of the Unit Lattices for Calcite and Rock Salt.. . .. . .F. C. BLAKE AND E. W. FORD
Laue Photographs of Piezoelectrically Oscillating Quartz Crystals, CARL E. HOWE
The Use of the F. P.-54 Pliotron in the Measurement of X-ray Absorption Coefficients . ...J. E. EDWARDS
Radiation Attending Low Critical Potentials in Mercury Vapor. (Preliminary Report) .... N. SHAWHAN
Experiments on the Tetrode Oscillator. .. . . W. C. SEARS
Stabilization of Oscillating Circuits used to Drive Quartz Crystals, D. W. BOWLAND
Heat of Vaporization and Charles' Law Apparatus for First Year College Physics .... C. W. JARVIS
Use of the Curved Mica X-ray Spectrograph in Undergraduate Instruction, J. F. HAINES
Dynamical Stability in Stars .... H. M. ROTH
Zeeman Effect Observations..... . ... R. A. LORING
Discussion on "The Preparation of Students for Graduate Work in Physics." PROFESSOR ALPHEUS W. SMITH will open the discussion and will present some of the difficulties encountered by students in their graduate work.
An Experiment with the Symposium Method of Teaching. (An attempted integration of the physical sciences on the nature of matter), WILLIAM LLOYD EVANS AND JESSE E. DAY
Fluorescence of Chlorophyll-metal Complex Salts, H. V. KNORR AND V. M. ALBERS
Frequency Determination with Demonstration.........THEODORE F. KUECHLE
Fluorescence of Chlorophyll a and b and Oxidation, V. M. ALBERS AND H. V. KNORR
Raman Spectra of a Series of Organic Chlorides.. ... .R. R. HAUN
The Gamut of Radiation .... W. R. PYLE
Demonstration of some New Mechanical Wave Models .... ISAY BALLINKIN
The Use of the Milling Machine as a Precision Optical Bench .JOSEPH JOHNSON
Repulsive Forces in the Heads of Comets .... N. T. BOBROVNIKOFF
Soil Development in Ohio ... .G. W. CONREY
Influence of Physiography in the Campaign around Chancellorsville, KARL VER STEEG
Topography and its Utilization in the Fiord Portion of Central Norway, GEORGE D. HUBBARD
Notes on the Vegetation of Ireland with Special Reference to the Limiting Factors of Geographical Distribution.. .... .A. E. WALLER
The Prairie Peninsula .... E. N. TRANSEAU
A Geographic Interpretation of Wheat Production on the Columbia Plateau, JOHN H. GARLAND
Some Elements of the Cultural Landscape on the Lake Plain of Northern Ohio, REUEL B. FROST
Nationalistic Elements in Farming in Northwestern Ohio CARL DUDLEY VARVEL
The Influence of the Charcoal Iron Industry on Southern Ohio ..WILBUR STOUT
Sequent Occupancy of a Village on the Ohio Till Plain....... ALFRED J. WRIGHT
A Phase of the Geography of Chattanooga.. . ... .N. C. BURHANS
Washington's Lands in Ohio . ...GUY HAROLD SMITH
Experiences in Giving Geography Instruction by Radio . . .. W. R. MCCONNELL
Factors Explaining Ohio's Freak Winter in 1932 ... . PARIS B. STOCKDALE

PRESIDENTIAL ADDRESS.

PHYSICS AND HUMAN EXPERIENCE.*

ALPHEUS W. SMITH.

We are living in a period in which our evident failure to understand and iterpret our human experiences, more and more fully justifies a sympathy with the mood of Mathew Arnold when he wrote,

> "And we are here as on a darkling plain,
> Swept with confused alarms of struggle and flight,
> Where ignorant armies clash by night."

The reason for this confusion and uncertainty in our social and economic life has been attributed in rapid succession to overproduction, overcapitalization, excessive developments in technology, inefficient means of distribution, high taxes and too much emphasis on scientific education, without pausing to recognize that the universe is a complex group of physical, biological and social phenomena which demand clarification and interpretation before human experiences can be organized and made the basis for future programs and policies. Indeed it does seem that science has produced a complex civilization which has far outrun our ability to control and direct social and economic phenomena, for a hasty survey of the achievements of science in the last century reminds us very vividly of the disparity between the brilliant advances in science and the ineffective methods for the control of public affairs. Hence we must recognize that while science has developed fabulous and undreamed of powers, we have yet to discover how they may be made most effective in the shaping of our social, economic and spiritual experiences. With this thought in mind John Dewey says "The great scientific revolution is still to come and it will ensue when men collectively and cooperatively organize their knowledge to achieve and make secure social

*There is no element of originality in this address. Even its phraseology is more or less common to all physicists. It only aims to organize simply and briefly some of the thoughts and points of view which are becoming a common heritage. In its preparation the following books have been of the greatest value: Eddington's "Nature of the Physical Universe;" Jeans' "The Mysterious Universe;" Darwin's "Modern Conceptions of Matter" and Dingle's "Science and Human Experience."

values." But the physical and biological sciences are human creations, universal in their origins and their outlooks and if we are to have a greater science it must also be of human origin and must arise out of a larger unity of thought and purpose which will draw together an incomprehensible wealth of physical, biological and social phenomena, and through its spirit and method will carry with it a rule of life and a vision without which the people perish.

Now it is impossible here to indicate the methods and scope of this science which shapes the material environment of our lives and forms the predominant constituent of our intellectual atmosphere. Nor is it my purpose to suggest that science offers a sure method of escape from the present or any future threat of doom. I only mean to suggest that the rapid advances in physical thought, especially in subatomic physics, suggest the type of thinking necessary for an interpretation and a correlation of those more complex human experiences found in the field of biology and social relations and for the building of an intellectual habitation which takes account of the fact that we are human beings living in a physical world. I am assuming that the material results of physics are immediately obvious to all but that its philosophical framework, its methods, its aims and its rigorous disciplines very largely escape those who have not had considerable experience in it or allied subjects. It will be sufficient therefore for my present purpose to make somewhat clear the method of modern physics—a method based on sound scientific thought supported by accurate and unambiguous experiments and to suggest that this type of thinking has great significance in other fields of knowledge and that it is perhaps the only type of thought which is sufficiently well founded to give us the confidence we need for vigorous and unhesitating action in social, economic and political affairs.

II.

It is the task of the physicist to reflect on the nature of the happenings in the physical world and to work out some scheme which will bring order and regularity into the conflicting appearances in which the tangle of physical phenomena manifest themselves. He deals entirely with the facts of observation and tries to reduce them to a system so that certain sequences of phenomena are necessary consequences of the system. He

of course must assume that there are universal regularities among physical phenomena and that there is an understandable organization in the physical universe and that these regularities and this organization may be described in terms of invariants which are in the long run independent of the observer and his mental attitudes. Each advance consists in bringing into this organized system a group of observed phenomena whose interpretation is in agreement with the general methods and principles of the system. The reasoning must begin and end with observation and no entities other than observable entities must be used in the analysis. The problem then becomes a game of putting observations into a framework of mathematical descriptions.

There are two methods of procedure and one or the other must be used according to the nature of the observations to be correlated. These methods are (1) the method of abstraction and (2) the method of hypothesis. Newton was the supreme exponent of the method of abstraction. He formulated principles which were inseparably wedded to the phenomena. This can not be done by formulating hypotheses for an hypothesis is only one of many possible guesses and it is impossible to know which of these guesses is the true one. Newton therefore relied on the method of abstraction. He says, "I frame no hypotheses. For whatever is not deduced from the phenomena is called an hypothesis and hypotheses whether physical or metaphysical have no place in experimental philosophy." But this attitude could not continue with the growth of physics and the increase in the complexity of the data. The period of Newton was in part superseded and in part supplemented by the period of hypotheses.

Every observer of physical phenomena before Newton must have inquired about the conditions which determine the path of a flying arrow, a falling stone or a rotating wheel. Yet before Newton all of these motions were without regularity or order. It took the genius of Newton to see the simple rule which unites and interprets them. To get this final rule Newton observed that there is a certain set of properties and characteristics in all bodies, independent of time and space—a set of characteristics which can be relied upon to help give a description of motions. This entity he called mass. From experiences arrived at from muscular exertions, he abstracted and generalized the concept of force. Experience having also

given the concepts of time and space, it was possible to deduce the idea of change of position in a given time and the rate of change of position or acceleration. With these three abstracted concepts he formulated the desired rule which describes the behavior of moving bodies. Then this whole complex system of physical phenomena became organized and systematic. One simple rule $F = M a$ simplifies and unifies the whole situation. The process has been to abstract from phenomena certain unchanging entities in terms of which phenomena can be described and put these entities together in a simple mathematical formulation. In other words the rule had been abstracted from the phenomena themselves. No hypotheses, verifiable or unverifiable are present in the process.

A continuation and an extention of this method gives the law of gravitation and the ordered motion of planets and other astronomical bodies. Here there is nothing about causes or effects. It is a description of regularities in terms of entities abstracted from the phenomena themselves.

The major illustration of the method of abstraction is found in the principle of relativity. Newton's laws of motion were understandable only if bodies with accelerated motion could be distinguished from bodies at rest or in uniform motion. To insure this differentiation Newton postualed absolute time and absolute space as independent entities. What happened here would happen there. There could be no differences in time. Now it was not necessary that absolute velocities be definitely observed. It was only necessary that such velocities could be definitely conceived. From the definition of absolute velocities easily followed definitions of relative velocities which were consistent with all experience up to Newton's time but the theory of relativity becomes a necessity when high speeds such as Newton had not occasion to consider became observed facts. Here the requirement that knowledge begin and end with experiment demands that we abandon the concept of absolute time and space. The result is that Newtonian velocity, acceleration and force have no meaning for these high velocities. Newton's scheme is incapable of correlating these experiences. A new scheme must be adopted. In this new scheme there is a union of time and space, remembering that the way in which they are to be united is determined by experiment. The result is as if we formed an abstract medium which has four dimensions, length, breadth, thickness and time instead of two

abstract media, time with one dimension and space with three dimensions. When described in terms of this new medium *space-time*, the laws of motion and gravitation are united. Instead of three abstractions space, time and force we have one *space-time*. Now here *space-time* is an abstraction from observation to describe experience. This is the greatest achievement of the method of abstraction. It dispenses with the force of gravitation as a means of description and gets the same results in terms of the properties of *space-time*. But after all Einstein has extended Newton and elaborated the Newtonian principles over a region of phenomena which Newton never knew. He has started with observation, abstracted certain concepts from these observations and subjected the conclusions to the test of further observation. Einstein's method is just like that of Newton but it is more comprehensive. He uses fewer and simpler abstractions but they are less familiar. His concept of a unified space-time absorbs all the Newtonian concepts of space, time, mass, gravitation, momentum, energy and electric and magnetic forces. It is a method of synthesis in which the phenomena of nature lose their individuality.

The interplay of abstraction, conceptual reasoning and hypothesis can be illustrated by a contrast of the attempts to describe physical phenomena in terms of particles and in terms of waves. At the very outset our sense perceptions gave us the concepts of particles, grains of sand or drops of water. But as smaller and smaller scale phenomena demanded interpretation, for example the diffusion of gases or the law of multiple proportions, it was necessary to reduce the size of this unit to smaller and smaller dimensions, ending for some time with the hypothetical atoms of Dalton which were not only unobserved but also unobservable. The properties to be assigned to these atoms were those necessary to make them capable of correlating the physical phenomena under consideration. For this purpose it was necessary to suppose that they were very small, hard, perfectly elastic spheres of infinitesimal mass, moving in absolute space and time and obeying those forces which had been found useful instruments of description and not necessarily entities which have physical reality in excess of that attributed to them for the explicit purpose of the description of phenomena.

When the discovery of the electron and the radioactivity

of certain elements brought forth facts which are not consistent with the older concept of an atom, it was necessary to introduce into the atom hypothetical concepts which with proper mathematical treatment are capable of describing these new phenomena. Just what new concepts were to be attributed to the atom were determined by the phenomena revealed by experiment. Any reasonable concept which proved helpful in the description of the phenomena might be added. However far the application of this method may lead us from the original ideas about an atom is not inconsistent with the best usages of physics. It only means that forty years ago the concept of an indivisible, unbreakable atom was sufficient to describe the then existing phenomena but this concept was to be shaped in the hands of the physicist as a sculptor fashions marble or bronze to express his ideas. The essential point of our present purpose is that, however, far the subdivision of the particle might be carried and however many and diverse concepts might be attributed to the particle, we have in the end a particle language in terms of which to describe physical phenomena, a language arrived at from sense perception but a language which is subject to experimental vertification. Now this language is extraordinarily but not universally successful in the description of the behavior of both matter and energy.

Fortunately sense perceptions give the physicist another concept—the concept of wave motion, which has proved equally important as a language in terms of which to describe physical phenomena. Suppose you drop a pebble into the surface of a pool of water. You find a system of waves going out from the center of this disturbance. If you observe the characteristics of this disturbance you can find a certain set of properties which can be abstracted from them, for example the wave length, the displacement, the frequency and the velocity. These universal characteristics we call the characteristics of a wave motion and find them useful symbols in terms of which to describe physical phenomena. We have now on our hands a second type of language in terms of which to correlate our observations and our ideas. We will be allowed to use whichever of these languages proves to be the most helpful for our purposes. The two types of language may after all be related to each other. Each may only be a half language to be later cemented into a completer language but for our present purposes we must use what is available.

Now let us try to describe some of the small scale phenomena in terms of particles. If we wish to describe the law of multiple proportions we need only think of small indivisible atoms. If we wish to describe the pressure exerted by a gas on the sides of the containing vessel, it is sufficient to make the particle a small perfectly elastic sphere and apply to it the ordinary laws of motion. If we wish to describe the discharge of electricity through a gas we must also assume that the particle is charged with negative electricity and that its mass is even smaller than that of the atom. Radioactivity will have an interpretation if we postulate two types of particles, one charged with positive electricity and the other with negative electricity. To account for other phenomena like band spectra, the atoms in the molecule must be supposed to vibrate with respect to each other and the molecule as a whole to rotate around one or more of its axes. We have thus added to the particle the possibility of vibration and rotation, concepts abstracted from gross phenomena. When we come to account for the spectra emitted by different atoms and through this data build up a picture of atomic structures, we assign to the electrons whatever characteristics are necessary for this purpose and develop a new system of mechanical laws. We supposed that the electron spins around its axis either in a clockwise or in a counterclockwise direction and has a magnetic field associated with it. By attributing to the electron these additional concepts which were already familiar from sense perceptions, a larger group of data can be correlated and wider range of physical phenomena can be interpreted. But this concept of spin and the concept of a magnetic field must not be thought of as having any ultimate reality in connection with the electron. They must be thought of as fictions which are capable of describing observable realities. On this basis any working hypothesis is a tool to be supplanted at any moment by a better tool. Notwithstanding its great successes the particle theory was not all powerful and we must look at its limitations and failures. The first of these appear in the hands of Newton the greatest proponent of the particle theory of interpretation of physical phenomena.

When light passes from one medium to another in which the velocity is different, its direction of propagation is changed. Newton tried to describe this result in terms of the language of the particle theory. The description was unnatural and

forced. When Young observed the interference of light there emerged a set of physical phenomena with which the particle theory could not deal, that is, there was no method of description in terms of particles to account naturally for the results. It occurred to Fresnel to undertake the description of these phenomena in terms of the language of waves. The result was conspicuously successful and it led to a great number of important extensions of our knowledge in the field of light. Maxwell then extended and generalized the concept of wave motion until it included electromagnetic waves as well as waves in some material substances. From this generalization and abstraction there emerges the electromagnetic theory of light. It is important to note the process involved in the extension and generalization of this theory. On last analysis it says that the language of waves is an adequate language in terms of which to describe these phenomena. It does not say that light is a wave motion. It only shows that the concept of wave motion can be very successfully applied to this field of physical phenomena as an effective and adequate means of description. On the other hand the language of particles has failed in its attempts to describe and correlate these same phenomena.

But careful experiments on light have revealed new facts which can not be described in terms of the language of wave motion. The simplest of these is the group of phenomena associated with the discharge of electricity from the surface of a metal when it is illuminated with light of a definite wave length. There is also the phenomena of black body radiation and the wealth of phenomena in the field of X-rays, atomic structure and spectroscopy. Indeed the experiments in the field of subatomic physics have added such a wealth of data in this region that an entirely new theory has been developed to take account of it. For our purposes it is chiefly necessary to emphasize the fact that at first this theory used the language of particles clearly in contrast to the language of the waves. In other words when the language of waves had failed to describe the phenomena of subatomic physics there wâs a return to the particle language of description and this form of description has been extremely successful in correlating the observed phenomena and predicting new phenomena.

When it appeared that the language of the particle theory was about to prove adequate for a description of small scale

phenomena it was discovered that it was necessary to use the language of waves to describe some of the characteristics of particles. Of course this important result completely changed our attitude toward the particle theory and very forceably reminded us that after all we are dealing with concepts abstracted from gross phenomena and using these concepts for the description and correlation of phenomena. The experiment of G. P. Thompson on the scattering of electrons illustrates this important development. Professor Thompson sent a beam of electrons through a thin sheet of gold foil and observed the pattern produced on a photographic plate. He found a series of diffraction rings which were almost identical with the rings which are to be found when a beam of light passes through a small opening. Now the patterns produced by the beam of x-rays or the pattern produced by the light passing through a pin hole have been very successfully described in terms of waves and this method of description proves to be equally successful in the interpretation of the results of passing the beam of homogeneous electrons through the metal foil. That is in the language of particles there is no way to correlate these observed results but when the language of the wave theory is used the results are easily correlated and it is possible to calculate the wave length of the electron in terms of its velocity and the diameter of the rings. These calculations check beautifully with the predictions of the theory. There seems no more reason for regarding the electron as entirely a particle than there is for describing radiation entirely in terms of waves. The result is that both the concept of waves and the concept of particles are needed to describe the electrons and both the concept of wave and the concept of particles are needed to describe light and other forms of radiation. The results of these and similar experiments have lead to wave mechanics in which subatomic phenomena are described in a remarkable way in terms of wave equations.

The electrons and protons are then no longer thought of as particles. They are endowed with properties which resemble waves. When mental pictures are necessary, we try to unite in our minds the images of particles and waves. To unite satisfactorily such divergent images is after all impossible and this fact teaches that the coneptions of space and time as abstracted from phenomena can not be applied directly to these subatomic phenomena.

The electrons and protons are now to be represented by mathematical symbols but we are not to give them pictorial properties. By means of these mathematical symbols their behavior can be worked out and an increasing number of observations can be correlated. Each new set of observations may require a modification or an extension of the concepts of the atom but these modifications and extensions must be consistent with the former concepts attributed to the atom. Thus the new atom is a set of consistent concepts subject to the primary test that they effectively correlate phenomena. The language of waves and the language of particles thus supplement each other. Each is a half word. Both are necessary for a complete description. The discoveries of recent physics lead then to the conclusions that electrons, protons and photons, can be regarded only as concepts, possessing no properties and subject to no laws other than those which are necessary and sufficient to correlate observations. The question whether they are real or unreal has no meaning. Since they are unobservable they are not real in the sense observed existences are real. In dealing with such hypotheses we have perfect freedom to shape them as we please, provided they achieve the end for which they were created. We are not bound to give them the characteristics of phenomena. They are employed for rational correlation and not admissible to experience. They must have rational properties but not necessarily sensible ones.

From these concepts we are at liberty to make any hypothetical inferences we may choose to make so long as these inferences can be verified by observation. If the inferences drawn from the hypotheses pass this test they have all the justification possible for them. But now it is conceivable that they may do this and yet not be the only set of inferences which would give the same results. In such an event we have no criterion for distinguishing between alternatives. Hence we are compelled to regard such hypotheses as concepts with no necessary likness to phenomena and no obligation to obey any laws except those by which they issue in phenomena.

These unverifiable hypotheses constitute a new instrument of scientific correlation. They are essentially different from that more familiar type of hypothesis which has essentially the nature of a potential experience. You can not ask whether such an hypothesis is true or false. All you can ask is, "Does it correlate phenomena in an effective manner?" It is merely

a mental edifice into which any ideas can be introduced so long as they cement together actual experiences. The recognition and use of this type of hypothesis gives the physicist an enormous increase of power. He is no longer restricted in his thinking to those elements which can be imagined. He does not need to confine himself to elements which can be clothed in the characteristics of phenomena. He can use any elements he chooses and let them interact with each other in any conceivable way, provided they give rational correlation of phenomena. But when these instruments of correlation have been used and they have been found successful, it must not be inferred that they are true or real in any sense other than that they are successful instruments of description. They only show that nature is rational or that out experiences are consistent with reason.

We must not fail to recognize that it was a significant point of departure when physics ceased to confine itself to things that can be observed directly and began to employ concepts that do not appear to the senses—that is, invented at the base of the world so called entities which are not capable of direct observation but entities which are necessary to account for the facts of observation. It would seem at first sight that physics which began with emperical facts was headed toward a reign of pure reason but this conclusion is too hasty. It does not give proper consideration to the experimental checks on the reasoning.

Never before has the intellectual horizon been so extended as it has been since the physical sciences began to apply these methods. In the direction of large scale phenomena we have arrived at an almost limitless space populated with spiral nebulae, more or less uniformly distributed through a sphere which is about one million light years in radius. In the direction of small scale phenomena, we have determined the essential constituents of the atom and their arrangement with respect to each other and are now addressing ourselves to the still more difficult problem of the nucleus of the atom. An unlimited number of physical phenomena lie between these extremes, ready to be understood by the extension of these methods. The possibilities seem to be limited only by the imagination, experimental skill and intellectual ingenuity of man. But we must ever keep in mind that the physical world is not merely the sum of all its parts. Its nature lies in its constitution

and organization rather than in its parts. The part in the whole is no longer the same as the part when it is removed from its neighbors. There may be separate electrons but when they cease to be separate they cease to have the same properties. The electron in the core of the atom is unlike the electron when it is removed from the atom. In the end this means as Russell states it, "The world ultimately consists not of material stuff but of patterns, or organization, the evolution of which involves no absolute creation of an alien world of material out of nothing."

III

The history of the biological sciences shows that they are developing along somewhat parallel lines. At first there was an accumulation of observational and experimental data without any real organization but when the cell was isolated and introduced as a unit in terms of which biological phenomena could be described, the science of biology made a real beginning. Conditions in the biological sciences before this time were not unlike those that obtained in the physical sciences before the time of Newton, where no one recognized regularities or uniformities in physical phenomena. But the cell was too large a unit for the description of all biological phenomena just as the atom was too large a unit for the description of all physical phenomena. When the concepts of the chromosone and the gene had been abstracted from biological phenomena, new units were available in terms of which it was possible to set up rules for the description of the essential facts of heredity. It is non-essential for my present purpose that two of these units are microscopic and that the other is beyond the range of the microscope. What is essential is that out of biological phenomena, certain biological concepts or entities were abstracted and that these entities are used as invariants in terms of which to express accurate relations between biological data. Here again as in physics it must be recognized that the unit is not necessarily unique. The unit in the presence of other units has new properties and the interactions between such units must be carefully considered. It is the organization as well as the unit that is significant and it must also be recognized that these concepts—cells, chromosomes and genes—are correct for our purpose just so long as they offer us means of expressing the rules which connect up biological data. When these

concepts cease to be effective for the correlation of biological phenomena they must be extended, revised or abandoned. Just as in the case of the atom and the electron, they are plastic material in the hands of the biological sculptor.

Perhaps that state of awareness which we call consciousness was the first concept to be abstracted from the group of phenomena which is now included in the science of psychology. This of course was a gross and poorly defined concept but it served to account for a great group of phenomena common to all sentient beings. Its introduction into the field of psychology is not unlike the introduction of the concept of mass into the field of physics only it was possible to make more precise definitions of mass than it has been ever possible to make of consciousness. Now mass proved an effective concept in terms of which to describe large scale phenomena like the motion of the planets but was nearly useless in the description of small scale phenomena. In an analogous way consciousness proved to be too inclusive a term for the description of much of the more detailed psychological phenomena and has in recent years been more or less dispensed with by one group of psychologists. All this group of psychologists mean by their attitude is that the concept of awareness has ceased to be a helpful concept in the description of the phenomena in which they are interested. It is not a question of whether consciousness is real or unreal. It is only a question of whether it is useful or otherwise. The situation is much like the attitude toward the ether. It was used in physics as long as it was a helpful instrument of description and it was abandoned when more effective means of description became available.

There, however, is little hope that the psychologist may follow with safety a practice which appears from time to time—the practice of trying to describe psychological phenomena in terms of protons, electrons and photons. There is little reason for supposing that we are going to be able for a long time yet to use physical concepts for the effective description of either biological or psychological phenomena. That may come some time but for the present we must expect to get our descriptions of biological phenomena in terms of biological concepts and our description of psychological phenomena in terms of psychological concepts.

So far as I know only one good illustration of this method of analysis has appeared in that group of phenomena we call

art. It is the attempt of Professor George D. Birchoff to apply a mathematical method to the analysis of certain forms of art. We are not interested in his results. He may or he may not be successful but his method is scientifically sound and for that reason interesting and suggestive. It amounts briefly to following the method of Newton in the formulation of the second law of motion, and abstracting from the phenomena of art three concepts which can be used as invariants just as Newton abstracted from physical phenomena the concepts of mass. Professor Birchoff unites these concepts through a simple mathematical equation which comes out to be the analogue of Newton's second law. He then follows the method of the experimental physicist, tests his mathematical relation by suitably selected experiments and rests his case on the results of these experiments. Nothing could be more straightforward and if the results prove negative in a particular case at least we are assured that the method is valid.

Now consider an illustration from the field of the social sciences. To understand the present financial and economic situation it would be necessary to abstract from a large group of such phenomena, one or more invariants in terms of which to make adequate descriptions. Perhaps we thought that we had such a unit or invariant in the American dollar or the pound Sterling but when we examine this unit we find that it is not even approximately an invariant but fluctuates over a large range of values. Yet in terms of this variable dollar or pound Sterling, used as an invariant, we have been discussing profits and losses, reasonable scales of wages and incomes, the cost of government and satisfactory standards of living. The reasoning in such a case is likely to be about as trustworthy as if a physicist were to undertake to calculate the orbit of Neptune on the assumption that the mass of this planet is constant and then find by later observation that the mass varies over a wide range of values. Professor Irving Fisher recognizes this point when he suggests that we try to define a dollar in terms of its purchasing power, as measured by certain accepted and suitable chosen standards. By a continual readjustment and revision of the dollar in terms of these price indices we might get a fixed standard of value for the dollar. We could then ask whether wages are going up or down, whether profits are too high or too low and whether there is the proper equilibrium between capital and labor. Until such trustworthy units or

invariants are available and until they are used somewhat as the corresponding units in the physical and biological sciences are now used there seems to be little hope for unambiguous and conclusive reasoning on social and economic problems. Until the conditions which make this type of reasoning possible have been realised, we may expect each generation to repeat the social and economic mistakes of the preceding generation.

This then is the suggestion of modern physics "to those who would not go round in an eddy of purposeless dust," the suggestion that we extend to human experiences those methods of description, interpretation and correlation which have proved so effective in the physical and biological sciences, the suggestion that we have not less but more science. As we see it here "lies the path of advance to a clear purposed goal but it leads up a long steep journey." Its appeal lies in its certainty and its challenge to the best collective and co-operative thinking which can be achieved through the progressive development of the human mind. Through it and it alone we may realize the hope of Henley,

"I am the master of my fate,
I am the captain of my soul."

AUTHOR'S ABSTRACTS AND BRIEF ARTICLES.

A. THE SECTION OF ZOOLOGY.

DR. DWIGHT M. DELONG, Ohio State University, Columbus, Ohio,
Vice-President.

Temperature and the Heart Beat in Caddis Fly Larvae:—By HENRY FEDERIGHI, Antioch College, Yellow Springs, Ohio.

The temperature characteristics for the rate of heart beat in the caddis-fly larvae *Psilotreta* are $u = 12{,}500$ and $13{,}500$, values which are indicative of activities probably controlled by the central nervous system. Analysis of data on the relation between temperature and the rate of heart beat in twenty-five invertebrates indicates that the value u for heart beat depends on the functional relationship between circulatory and respiratory systems.

Ecology of Ohio Band-Winged Grasshoppers: Orthoptera, Acrididae, Oedipodinae:—By E. S. THOMAS, Ohio Archaeological Museum, Columbus, Ohio.

These attractively colored insects are without exception xerophilous and geophilous. They are characterized by protectively colored tegmina and bright-colored wings. All have the ability of producing at will a crackling sound when on the wing, and, in addition, a stridulation while on the ground, by rubbing the hind femora against the roughened intercalary vein of the tegmina.

Four species winter in the nymphal stage, (our only species of grasshoppers to do so), the remainder wintering in the egg. All Oedipodinae lay their eggs in the soil.

Two explanations may be given of the significance of the bright wings in the economy of the insects: (1) Vosseler has suggested that the protectively colored tegmina and bright-colored wings constitute a contrast mimicry; (2) they may serve as a means of signalling or attracting the attention of other members of the community.

Three of the Ohio species are meso-xerophilous, inhabiting situations where the vegetation is relatively dense. The remaining 13 are xerophilous, some of them highly so. Five species occupy old fields and dry, upland pastures; 3 are found on eroded slopes and washes; 2 inhabit "dry prairie;" 2 are thamnophilous or even sylvan to a greater or lesser extent, and 3 are arenicolous, being found on sand dunes, sand bars along streams and sandy fields, respectively. Dissosteira occupies a wide range geographically and ecologically, but always xeric situations.

Observations on Two Nests of the Black-throated Green Warbler:—By MARGARET MORSE NICE, Columbus, Ohio.

Two nests of *Dendroica virens virens* were watched in Pelham, Massachusetts, in July and August, 1931. The first female during the two last days of incubation incubated for periods ranging from 34 to 50 minutes, absenting herself for periods ranging from 9 to 26 minutes. The second female once incubated for 99 minutes at a stretch; her absences varied from 13 to 20 minutes. The three young in the first nest were raised with no assistance from the male until the last two days when he brought 11 meals in contrast to his mate's total of more than 245 in 80 hours. The two young in the second nest were raised entirely by the female.

Both females fed at slow rates, the average for the first being once in 19.7 minutes, for the second once in 16.3 minutes. The young left at the age of 8 and 9 days. The male of this species possesses extraordinary energy for singing; the warbler of the first nest gave 466 songs in a single hour and 13,962 in the 94 hours of observation.

A Preliminary Report on the Food Habits of the Barn Owls at Ohio Wesleyan University:—By ARTHUR STUPKA, Ohio State University, Columbus, Ohio.

One year ago the writer collected 637 Barn Owl pellets in the attic of Merrick Hall, on the campus of Ohio Wesleyan University. These, upon examination, yielded a total of 2,000 skulls—chiefly skulls of mice and of such other smaller mammals as fall prey to these raptorial birds. Skulls from other pellets collected at the same time in the belfry of Gray Chapel, on the same campus, brought the total number examined to 2421.

A summary of this examination is as follows:

Six species of mice made up 75 percent of the food of the Barn Owls at this locality, twenty-one percent consisted of two species of shrews, two percent consisted of other small mammals, and two percent consisted of small birds.

A Study of the Large Banana Spiders:—By ROBERT L. BAIRD, Oberlin College, Oberlin, Ohio.

These large Tarantulas are commonly feared and regarded as deadly as rattlesnakes. But these kept in captivity have been handled freely without trouble. They have fed on grasshoppers, crickets, cabbage butterflies, a mouse that had been killed and given them, a large cecropia moth. Live mice have been put in with them, but they have done nothing with them. Once they have fed on night crawlers. Some have experimented further and had themselves bitten by them. None that come here in bananas seem to be dangerous. The Black Widow is the only North American spider that may be dangerous and it is a very sluggish one, almost impossible to make bite. From actual personal experience I know of no deaths resulting from its bite. Spiders are often blamed for human ills with which they have no connection. Apparently the only remedy needed is to hold the bitten member in

hot water or if aches have spread through the body to take frequent hot baths. It is not at all necessary to cut out the wound or bleed it.

Growth in Daphnia Magna:—By BERTIL GOTTFRID ANDERSON, Biological Laboratory, Western Reserve University, Cleveland, Ohio.

Observations as to the number of pre-adult instars have been made on over 200 individually reared female *Daphnia magna* of seven clones. In all cases measurements of the total length during each instar were taken. For well over a hundred individuals measurements of carapace length and height were taken in addition to those of total length.

The number of pre-adult instars varied from five up. This variation was found in all clones tested.

Growth curves have been constructed for various groups based on the number of pre-adult instars. The inflection in the growth curve of any dimension in any group coincides with the time of sexual maturity.

"Brooks' Law" of growth holds only for those groups which were primiparous during the sixth instar and then only approximately.

Relative growth in the dimensions studied follows the law y = bxk. Relative growth changes at sexual maturity, i. e., a change occurs in the values of the constants *b* and *k*.

Notes on Macrobrachium (Palaemon) ohionis—Large Freak, Water Shrimp:—By ROBERT N. MCCORMICK, Ball State Teachers College, Muncie, Ind.

A relatively little-known shrimp, large enough to be of economic importance, exists in certain portions of the Mississippi River and its tributaries. It is locally used as fish bait and is marketed as human food. Throughout a part of this drainage system, this species apparently replaces the crayfishes. It was described in 1873 as *Palaemon ohionis* by Sidney I. Smith, from specimens sent from the Ohio River. Stephan A. Forbes, in the first Bulletin of the Illinois State Laboratory of Natural History, 1876–83, listed this form and left a note as to its distribution and variation in size. It has appeared in the diagnostic keys of Kingsley, of A. E. Ortmann and of H. S. Pratt, but to our knowledge, no figure of it has been published.

Dr. Waldo L. Schmitt, after a study of African Collections, has placed this shrimp in the Genus Macrobrachium.

The present study has been based on various collections from the Mississippi River near Chester, Illinois, material from Louisiana, observations of the live specimens after a year in captivity, and also of these very transparent living organisms under a binocular microscope.

On Eucrangonyx mucronatus Forbes: A subterranean, Blind Shrimp now Reported from Ohio:—By S. R. WILLIAMS, Miami University, Oxford, Ohio.

This fresh-water crustacean was first reported by Forbes from wells and springs of McLean County and Champaign County, Illinois, in 1876.

O. P. Hay found it in an old well in Marion County, Indiana, in

1879 and in 1931 it was pumped from a well on the Francis farm in Ross Township, Butler County, Ohio.

An inspection of the glacial maps shows these localities are all close to the boundary of the Wisconsin, or last glaciation.

The question as to whether an animal goes into a subterranean habitat and then loses its sight by disuse or whether the creature, already a blind form, finds itself in the darkness and stays there because adapted to a cave life, seems definitely settled in the case of this eugrangonyx. Each isolated locality in which it may be discovered is a cumulative proof that the species, an inhabitant of deep, therefore dark and cool water and already blind, was left in underground passages in front of the melting glacier and in those spots where there has been a sufficient supply of food and of cool water has persisted through the fifteen to twenty-five thousand years since the final retreat of glaciation.

The logical inference would be that far north this same species should still be an inhabitant of deep, dark, cool places in the surface water.

Food Habits of Some Ohio Raptorial Birds:—By ARTHUR STUPKA, Ohio State University, Columbus, Ohio.

In November of the past year the Ohio Division of Conservation started a campaign against the wild-life predators of game birds and game mammals. Two methods were employed, namely, shooting and pole trapping. In an effort to obtain as much information as possible regarding all raptorial birds taken during the course of this campaign, the Bureau of Scientific Research sent word to all its game protectors to send all hawks and owls to the Ohio State Museum where it was the work of the writer to examine their stomach contents. To date 693 raptorial birds, representing 14 species, have been received.

The stomach contents of a great majority of the birds examined showed them to be of real economic benefit. Of 693 stomachs examined, 12 contained game birds, 17 contained poultry, 92 contained other birds, 285 contained mice, 53 contained shrews, 19 contained rabbits, 20 contained other mammals, 2 contained snakes, 16 contained crayfish, 6 contained spiders, 44 contained insects, and 206 were empty.

Pole trapping will cease in the state on June 1. Abolishment of the bounty system, elimination of the mythical "blue hawk" and "chicken hawk" from the list of unprotected birds, and strict supervision of any pole trapping are recommendations which the results suggest.

The Fresh-water Medusae of Vermillion River, Ohio:—By ROBERT L. BAIRD, Oberlin College, Oberlin, Ohio.

Two objects in this paper: To record the findings of the Fresh-water Medusae in Vermillion River, Ohio, September 14, 1930, by Robert Helfer, a West High School boy of Cleveland, Ohio; and secondly, thus to emphasize the importance of helping junior or amateur naturalists and encouraging them in every way possible. There are two previous Ohio records. The first was reported by Dr. R. C. Osburn, Head of the Zoological Department of Ohio State University, in Sep-

tember, 1926, when the animals were first found by Charles Cooper, Jr., of Coshocton, Ohio, a high school boy. The third was made by students of Ashland College. These were found in a quarry near Ashland, in September, 1930. A fourth record is just reported through the presenting of this paper and has been verified. Roger Conant, Educational Director of the Toledo Zoological Society, found them in a quarry near Toledo, October 6, 1931.

Most of the specimens have been lost. They may be satisfactorily preserved by first numbing them by dropping a few crystals of menthol in the water or crystals of chloral hydrate till the animals cease to move and then adding enough 40% solution of formaldehyde to make a 3% solution. All the specimens found in these records have been females.

A Cytological Study of the Glandular Epithelium of Lumbricus:—By THURLO B. THOMAS, Oberlin College, Oberlin, Ohio.

A study has been made of the cytology of the gland cells in the epidermis of *Lumbricus terrestris* on living and fixed material. For the most part the observations were confined to the 5th, 6th and 7th segments where the cells are much taller than in the stomach-intestine region. It is concluded that (1) with the possible exception of strictly sensory cells, any cell in the skin of these segments may produce mucous; (2) the gland cells do not contain fat; (3) both the small and large globules are stages in the production of mucous rather than being two types of glands as reported by former workers; (4) the mucigen granules arise as aqueous vacuoles stainable vitally with neutral red and become more concentrated by absorbing materials from the cytoplasm. It is suggested that either all or a part of the lipoidal material in both the mitochondrial and diffuse lipoids is utilized in the synthesis of the glycoprotein mucin.

The Reactions of Certain Cladocera to Colored Lights of Equal Intensity:—By HYMEN LUMER, Western Reserve University, Cleveland, Ohio.

Numerous investigators have studied the reactions of Daphnia to colored lights obtained by means of either a prismatic spectrum or colored media, and have found that the stimulating efficiency of the light increases from the violet to the red, green light having the maximum efficiency. In these experiments, however, no attempt was made to eliminate accurately effects which might be due to intensity differences. Moreover, scarcely any work has been done on other cladocera.

In our experiments, colored lights were obtained by means of a series of thirteen filters of known wave-lengths and energy transmission. For each filter, the source of light was placed at such a distance that the intensity of the light striking the animals was the same in all cases. Four species were investigated—*Daphnia pulex*, *Daphnia magna*, *Moina brachiata*, and *Leptodora kindtii*. The animals were exposed to the series of lights, and the number positive to the light counted after each exposure. The percent of the total number positive to each color was then determined.

It was found, in harmony with previous results, that the stimulating efficiency increased from the violet to the red. The maximum, however, was found to occur in the orange (620–640 $\mu\mu$), not in the green, although for *Moina brachiata* the efficiency of the two colors was about equal. This discrepancy is most probably due to the fact that colors equal in intensity were used here, and not in previous experiments.

The curves for the distribution of stimulating efficiency, although essentially similar, differ in certain details, indicating that the photochemical substances present are specific, although fundamentally alike. It is interesting to note that the curves most alike are those for *Daphnia pulex* and *Leptodora kindtii*, which are the least closely related of the species investigated.

The Phaenogenetics of Drosophila funebris:—By WARREN P. SPENCER, College of Wooster, Wooster, Ohio.

The genetic picture of *Drosophila funebris* differs markedly from that of other species of Drosophila which have been investigated. Of the approximately seventy visible mutants known, 58% affect the wings in shape, size and venation and about 28% are bristle mutants. There is only one eye color mutant in the list. In *Drosophila melanogaster* wing mutants are 25% of the total and bristle mutants about 12%. Color mutants are 36% of the total in melanogaster as against less than 2% in funebris. The dominants in *D. funebris* make up 40% of the total visibles while in melanogaster they form approximately 29% and in hydei 20%. Character expression of 60% or more of the funebris mutants is very variable with many normal overlaps. This is not the case with other Drosophila species. Temperature has been shown to affect the grade of expression of a number of the funebris mutants. The species is poorly adapted to studies on linkage, but excellent material for the investigation of gene manifestation in terms of environmental variables.

The Effect of Strychnine Sulfate upon the Melanophores of Eupomotis gibbosus:—By GEORGE RUGGY, College of Wooster, Wooster, Ohio.

In an attempt to throw some additional light upon the subject of the control mechanism of the melanophores of fishes, a series of experiments were undertaken to find out the effect of strychnine upon these cells. Experiments were made upon the isolated melanophores by placing them, contracted and expanded, in a graduated series of solutions of strychnine sulfate in normal saline. They showed no reaction. Then this same series of solutions were injected introperitoneally into three-inch specimens of *Eupomotis gibbosus* (the common sunfish) and peculiar reaction of the melanophores was observed. It consisted of rhythmic contraction and expansion of the melanophores and was called a "wave phase." It seemed due to the lowering of the synaptic resistance which is the characteristic effect of strychnine.

It was concluded that the melanophores are pre-eminently under the control of the sympathetic nervous system.

Winter Feeding of Game Birds:—By LAWRENCE E. HICKS, Ohio State University, Columbus, Ohio.

Upland Game Bird research studies in Ohio conducted for the Ohio Division of Conservation have been carried to each township of the 88 counties of the state. An ecological survey is being made in an attempt to (1) evaluate the possibilities of each area for the several game birds and related species involved, (2) make an analysis and comparison of habitats found, (3) make a summary of all biotic changes taking place which might affect game birds and (4) correlate the abundance and distribution of each species in relation to geological divisions, ecological types and specific man-induced conditions.

With this information it is hoped to (1) estimate eventually rather accurately the ability of any given land area to produce game of a certain species under present conditions, (2) estimate the possibility of increasing the game production ability of a particular area by man control of many environmental conditions (management), and (4) to determine what steps will be necessary to increase most efficiently land game bird production capacity with the least expenditure of time, effort, and money and the least interference with agricultural and forestry activities.

During the winter of 1930–31, 20 winter feeding stations were established in central and northwestern Ohio. Studies at these stations aided greatly in the solution of many of the problems outlined above. These feeding areas covered 4,125 acres of land and a total of 2,702 game birds were fed, including 1,869 Ring-necked Pheasants, 605 Bob-white, 228 Hungarian Partridge and several hundred smaller birds. Topics studied were necessity of feeding, desirability of various foods and cover, mortality, sex ratios, fluctuations in numbers, etc.

Winter feeding and management studies have made it possible to develop a Ring-necked Pheasant refuge policy which it is hoped can soon be put into operation. Such a plan is workable and relatively inexpensive, as has already been shown by experiment and is the only plan which will supply game birds in numbers sufficient to meet the excessive demands.

B. THE SECTION OF BOTANY.

DR. ARTHUR T. EVANS, Miami University, Oxford, Ohio, *Vice-President.*

The Forests of the Illinoian Drift Plains of Southwestern Ohio.—By E. LUCY BRAUN, University of Cincinnati, Cincinnati, Ohio.

The area considered consists of the flat and undissected portions of Clermont, Brown, Warren, Clinton and Highland counties in southwestern Ohio—the area of the Illinoian drift. The Clermont silt loam or "white clay" is the prevailing soil; other types are recognized, though less extensive. Topographic development and successional

stage affect the composition of the forest. In second growth forests, pin oak is dominant. In primary stands, several distinct associations are distinguished and related in part to water content of soil and soil differences. The probably post-glacial development of the forests of these areas is outlined, with evidence offered from distribution of communities around depressions, from secondary succession, and from the geographic distribution of certain characteristic species of the area.

An Instrument for the Accurate Quantitative Determination of Chlorophyll:—By R. E. OLTMAN, Oberlin College, Oberlin, Ohio.

Because the colorimetric method of chlorophyll estimation fails to detect slight differences in chlorophyll concentration, and the spectrophotometric method involves the use of apparatus not always available to botanists, the present apparatus has been devised. A light beam of unvarying intensity is converted to wavelengths approximating those of the absorption bands of chlorophyll, by means of a colored slide. The light beam passes through an absorption cell containing a solution of the potassium salt of chlorophyll, upon the face of a photo-electric cell, which registers the intensity of the beam upon a sensitive microammeter or galvanometer. The preparation of chlorophyll for use in the apparatus is described, and lantern slides employed, illustrating the calibration of the instrument. The instrument is easily constructed at a cost of less than $30.00 for parts and materials.

The Effect of Ultra-violet Light of Various Wavelengths on Pigmentation and Growth of Bean Seedlings:—By R. E. OLTMAN, Oberlin College, Oberlin, Ohio.

By means of Cellophane filters soaked in organic compounds, several cut-offs in the ultra-violet are procured. A G. E. S-1 lamp is used as the ultra-violet source, and bean seedlings treated with filtered and unfiltered ultra-violet light. The pigments are extracted and the concentrations, as developed under different wavelengths of ultra-violet, are measured and contrasted. Results indicate a considerable increase in chlorophyll concentration is effected by unfiltered light from an S-1 lamp, while varying degrees of increase over normal pigment concentration are effected by filtered ultra-violet. Controls are grown under an ordinary Mazda lamp, whose visible light energy is adjusted to equal that of the S-1 lamp. Results indicate that many of the effects upon growth of plants, attributed to ultra-violet light, are due merely to an increase in the amount of *visible* light supplied by the ultra-violet source. Quantitative determination of chlorophyll is effected by means of the instrument described in the preceding paper. To be illustrated with lantern slides.

C. THE SECTION OF GEOLOGY.

PROF. E. M. SPIEKER, Ohio State University, Columbus, Ohio, *Vice-President.*

The Stolons of the Trepostomata:—By GEORGE B. TWITCHELL, 845 Dayton Street, Cincinnati, Ohio.

Zoarial stalks in many encrusting organisms appear as recumbent individuals which subsequently become erect. Where buds arise serially from bases of stalks, the recumbent portions, following one another, suggest that the stalks may have arisen from stolons.

A true stolon, however, is not formed in this way. A true stolon forms a zoarial bud at its growing tip, but its growth continues beyond the zoarial stalk produced to form a base (stolon) for the next stalk.

It is in the Entoprocta, among living bryozoans, that we find such stolons. Here the stolons are divided into segments by perforated diaphragms with the zoarial stalks arising from their middles.

It has generally been accepted that the Trepostomata budded and formed new stalks, like the Cyclostomata, without the formation of true stolons. This idea has received strong support from the work of Cumings. What I expect to present to you here is that the Trepostomata, at least most of them, arose from true stolons and that these stolons had the characteristics of the stolons of the Entoprocta.

Wherever Trepostomata arise from a so-called epitheca, sections show that the epitheca is made up of tabulated tubes, stolons. A similar arrangement can be found when the bryozoans are attached and no epitheca apparent.

Acanthopores are common in the early immature region and are not limited to the mature region. This occurs on the stalks much as spines occur on Pedicellina echinata. The wall pores and spines of the Entoprocta are relics of the acanthopores of the Trepostomata.

A Possible Pseudobornia from the Ohio Shale:—By WILLARD BERRY, Ohio State University, Columbus, Ohio.

A remarkable long branch and stem or stem and rhizome collected from the lower three feet of the Ohio Shale as exposed at High Banks on the Olentangy River north of Worthington, Ohio, and referable to *Pseudobornia inornatus* (Dawson) White is identified as *Callixylon newberryi* (Dawson) Elkins et Wieland as that species is interpreted by Arnold.

Base Saturation as an Indication of the Extent of Teaching in Surficial Materials:—By G. W. CONREY, Ohio Agricultural Experiment Station, Wooster, Ohio.

It is the common practice to determine the extent of leaching in surficial materials, by a determination of the depth to carbonates, as indicated by effervescence with acid. This shows the depth to which carbonates have been removed from the soil, but tells little or nothing about the condition of the material above. The reaction of surficial material expressed as the pH value has also been used as an indicator.

As surficial materials weather there is developed a complex capable of absorbing bases. In the calcareous soil this complex is saturated with bases, but after the carbonates are gone there continues to be a removal of base from the absorbing complex and a substitution of hydrogen. The relation of the amount of bases absorbed to the total capacity to absorb bases is spoken of as the degree of saturation. As soils become more leached, they become less saturated with bases, and more saturated with hydrogen. Data is presented to show the extreme low degree of saturation of soils derived from the Illinoian drift as compared with the Late Wisconsin drift in western Ohio. Both soils are non-calcareous, although the parent material is high in lime. Considerable areas of drift in northeastern Ohio are naturally non-calcareous, being derived from sandstone and shale which contain little or no carbonates. The extent of leaching is well expressed by the degree of saturation.

Salient Features of the Appalachian Valley in Virginia:—By ARTHUR BEVAN, Virginia Geological Survey, University of Virginia, Virginia.

The Appalachian Valley and Ridge province occupies all of Virginia west of the Blue Ridge province, except the extreme southwestern part of the State which is in the Appalachian Plateaus. The Valley in Virginia is almost 400 miles long in a southwesterly direction, about 25 to 50 miles wide, and contains approximately 10,000 square miles. Its southwestern tip is at the longitude of Toledo, Ohio.

The Valley contains, according to the recent work of Butts and Ulrich, probably about 40,000 feet of Lower Cambrian to Upper Mississippian (Chester) sedimentary rocks. Single shale and limestone masses are a few thousand feet thick. The basal part of the section is dominantly sandstone, the lower middle part is mainly limestone and dolomite, the upper middle part is chiefly shale, and the upper part is shale and sandstone with considerable limestone in the southwest part of the Valley.

The structural pattern comprises (1) many large pitching anticlines and synclines, having in general a northeasterly strike and being overturned to the northwest; (2) numerous great overthrust faults, overriding to the northwest; (3) numerous fensters; and (4) scattered klippen. The horizontal displacement along some faults is probably of the order of several miles to a few tens of miles and the stratigraphic displacement in places causes Middle Cambrian to overlie Upper Mississippian or even Pottsville rocks. One overthrust is known to extend from Tennessee for more than 200 miles in Virginia. These features have been worked out mainly by Butts, Campbell, Holden, Stose, and Woodward.

Post-Paleozoic erosion has produced a recorded series of five erosion levels; the upper two being prominent on the long, linear, even-crested mountain ridges, and the next to the last one being conspicuous as the extensive trenched Valley-floor. Physiographic salients have been worked out chiefly by Stose and Wright. Many drainage peculiarities have been developed. Underground drainage and numerous large spectacular caverns are characteristic of certain belts of limestone.

Pre-Cambrian Geology in Central Virginia:—By A. S. FURCRON, Western Reserve University, Cleveland, Ohio.

This paper will discuss the structural, stratigraphic and perrographic features of pre-Cambrian geology in central Virginia. A brief outline of the history of the study of crystalline rocks in this part of the State will be given which will include a summary of present knowledge. It will contain an interpretation of present pre-Cambrian problems based upon the recent writings of geologists who have made a study of this region and upon a study by the writer of about 800 square miles in the Piedmont Plateau and Blue Ridge provinces. The paper will be illustrated by monochromes and autochromes.

Solution Phenomena in the Basal Oneota Dolomite:—By WM. A. P. GRAHAM, Ohio State University, Columbus, Ohio.

The lower contact of the basal dolomite bed of the Oneota formation of Minnesota is sometimes found to be very irregular. Where these irregularities are developed the dolomite is strongly jointed. Settling of the overlying dolomite, following solution, has resulted in the deformation of the underlying clastic material.

Glacial Limestone Deposits Near Mt. Liberty, Ohio:—By RICHARD C. LORD, Kenyon College, Gambier, Ohio.

In southeastern Morrow County and southwestern Knox County near Mt. Liberty, Ohio, is an area some six miles by one-half mile where the glacial till contains in certain places an accumulation of pieces of limestone, up to two or three cubic feet in size.

Three out of four analyses of sample pieces were dolomite, the fourth a limestone containing nineteen percent magnesium carbonate.

This occurrence of limestone in glacial till indicates that the ice by which these were carried passed over the Monroe (dolomite) and lower Devonian (limestone) west and northwest of this glacial deposit in its course.

The movement of the last ice sheet in this locality was thus in an easterly or east-southeasterly direction.

Between 1820 and 1860 this accumulation of limestone boulders by the ice was used to obtain lime for building purposes by local burning of the lumps of limestone.

Pre-Cambrian in Ohio:—By GEORGE D. HUBBARD, Oberlin College, Oberlin, Ohio.

Many well drillings over nearly all parts of Ohio reveal a rather orderly succession of strata. Three or four wells have gone through the sediments to pre-Cambrian rocks. These testify to the form of the surface upon which the Cambrian rock sediments were laid.

Pre-Cambrian, where exposed, shows complex rock structure and often considerable mineral wealth—iron, nickle, cobalt and some gold and silver. Torsion balance and other methods of physical surveying at the surface have shown their usefulness in detecting geologic facts beneath a mile or more of sediments, especially when so uniformly

laid as ours are. Perhaps a survey by geophysical methods over the western half of Ohio would be worth while.

Net-work Passages and the Origin of Limestone Caverns:—By A. C. SWINNERTON, Antioch College, Yellow Springs, Ohio.

The two-cycle theory of cavern formation in limestone proposed by William Morris Davis finds a measure of support in the presence of looped and net-work passageways in many caves. Recent investigations in the Mammoth Cave region suggest ways in which such openings may be reconciled with other theories of cave origin.

The Caves of Yarim Burgaz, Turkey:—By GEORGE D. HUBBARD, Oberlin College, Oberlin, Ohio.

Caves about 12 miles west of Istanbul made before the recent small submergence have passed the enlarging stage and entered the filling stage as many stalactites show. But the drip goes down to lower levels not yet seen, indicating that a new system is being formed below the known one. Bats are common in the cave. Two green salamanders were taken in the first chambers. The main cave has been used for human residence and for burial, as shown by three graves, one-fourth mile from the entrance and two near the entrance. These are prehistoric. Shepherds have used it also in modern times.

Some Features in the Drainage History of the Upper Ohio:—By G. F. LAMB, Mount Union College, Alliance, Ohio.

The preglacial northward drainage of the Upper Ohio has long been established. Late Tertiary and early Pleistocene stream grades were at high levels with distinctly lower levels at later glacial stages. The East Liverpool-Beaver section affords a key area and presents three distinct stream levels and deposits of as many glacial stages—Wisconsin, Illinoian, and an older stage of Parker Strath time or older. After early glaciation the temporarily diverted Upper Ohio returned to the Erie basin, cutting the deep inner channel before the Illinoian invasion. This latter ice sheet permanently reversed the Upper Ohio.

Abnormal drainage features south of the New Martinsville divide point to a progressively northwest shifting divide with striking stream captures that were in progress before the glacial epoch.

Drainage Changes of the Upper Mahoning River:—By ROBERT SCRANTON AND G. F. LAMB, Mount Union College, Alliance, Ohio.

Findings in a recent study of the drainage of the upper Mahoning River appear to reveal a somewhat complicated history. It has been thought that the present Mahoning follows essentially its preglacial course to its junction with the old Pittsburgh River near Leavittsburg. Field data indicate that the preglacial upper Mahoning was not a tributary to the old Pittsburgh River, but followed a course from Alliance to Ravenna, passing near Kent, then northward through the Chagrin River Valley and into the Erie basin, thus draining a distinctive area lying between the Cuyahoga basin on the west and the Grand River

basin on the east. It is thought that the deep channel was cut in interglacial time prior to the Illinoian invasion, that with the Illinoian advance the drainage was diverted eastward at Ravenna into the reversed Pittsburgh River, and that all the upper Mahoning held this drainage line until the Wisconsin invasion, and after this invasion took the course now occupied from Alliance to Leavittsburg.

D. THE SECTION OF THE MEDICAL SCIENCES.

DR. SHIRO TASHIRO, University of Cincinnati, Cincinnati, Ohio,
Vice-President.

The Effect of Various Stimuli on the Basal Metabolic Rate, the Blood Pressure, and the Galvanic Skin Reflex in Man:—By E. ROWLES AND J. R. PATRICK, Ohio University, Athens, Ohio.

Using the Benedict-Roth basal metabolism apparatus, the Tycos sphygmomanometer with a reducing capsule and tambour attached, and the Hathaway psychogalvanometer with a Ruckwick photographic apparatus attached, the experimenters ran a series of control tests, first basal alone, second, with sphymomanometer and other apparatus attached and operating. After several records under normal conditions were taken the subjects were subjected to various stimuli of a "sensory" and "ideational" nature to note the effect of these stimuli on the basal metabolic rate, the blood pressure, and the galvanic skin reflex. Male college students, with one exception, were used as subjects under rigidly controlled conditions. The results so far obtained from this preliminary investigation seem to show: (1) that all subjects, with one exception, show an increase in the basal metabolic rate above the normal and the control rates of 9% to 38% when subjected to various stimuli which supposedly have an emotional effect; (2) blood pressure changes occur following the application of most of the stimuli; (3) while the data is not as complete on the galvanic skin reflex, the data that has been secured shows a deflection of varying degrees following the application of the stimuli; (4) whether the peripheral changes occur first, later followed by more deep-seated changes as cardiac and metabolic, have yet to be determined more precisely, or again, whether this technique will differentiate the effects of the various stimuli is yet to be determined.

The Ultra Violet Absorption Spectra of Vitamin B Concentrates as Correlated with their Potencies:—By FRANCIS F. HEYROTH AND J. R. LOOFBOUROW, University of Cincinnati, Cincinnati, Ohio.

The preparation of three vitamin B (chiefly B_1) concentrates from yeast is described. In biological tests by the M. I. Smith rat curative method, which is discussed critically, H_1 proved relatively inactive, H_2 cured the symptoms described in a minimal dose of 0.04 mg., and H_3 in one of 0.16 mg.

The ultra violet extinction coefficients of these and other concentrates kindly furnished by Drs. A. Seidell and L. R. Cerecedo, have been determined and a series of curves plotted. All show evidence of the type of absorption previously attributed to pyrimidines or irradiated pyrimidine-containing materials. The attempt is made to correlate this absorption at various wave-length regions before and after correcting for the possible presence of nucleic acid, with the relative potencies of these samples. It is probable, although not proved, that the biologically active material may absorb between 2300 and 2500 A°.

A Physiological Mechanism in Control of Blood Coagulability:—By DON D. IRISH, University of Cincinnati, Cincinnati, Ohio.

Tissue extracts and their decomposition products which affect coagulability in vivo owe their action to a physiological mechanism. The spleen is the organ which reacts to these materials as they are inactive in the absence of the spleen. The response of the spleen is manifest as a sharp increase in the number of platelets per cu. mm. of blood. Splenectomy is followed by a high platelet count which falls to a base level in about two weeks. It remains at this base level indefinitely, showing none of the erratic changes of the normal and unaffected by materials mentioned above. The spleen acts as a reservoir for platelets and may be called upon in an emergency to produce a great increase in their number and produce it quickly.

On the Chemistry of the Hinton Test for Syphilis:

(1) *Nature of the Muscle "Antigen:"*—By SHIRO TASHIRO, University of Cincinnati, Cincinnati, Ohio.

The general method of the preparation of "antigen" in various precipitation tests for the diagnosis of syphilis and the particular technique used in the Hinton test suggest that "antigen" might contain a bile salt. The results of chemical and physiological analysis support the idea and further suggest that the presence of a bile salt plays an essential part in all the precipitation tests.

(2) *A Synthetic "Antigen."*—By MISS CHRISTINE M. VACK, University of Cincinnati, Cincinnati, Ohio.

The antigenic properties of various known mixtures of lecithin, cholesterol, and bile salts were investigated in syphilitic sera. The Hinton technique was used. Lecithin was found to be essential for the reaction, but increments of lecithin, when bile salt and cholesterol concentrations were constant, did not increase the specificity of the test. On the other hand, increments of bile salt, when lecithin and cholesterol concentrations were constant, increased the specificity in direct proportion to the amount of bile salt used. Neither variation of cholesterol content or the percentage of glycerol in which the antigen was made up, increased the specificity of the test. Addition of a small amount of urea to a synthetic antigen increased the ease of reading, and eliminated false weakly positive reactions.

Hematoporphyrin, an Artificial Proteolytic Enzyme:—By M. J. BOYD, University of Cincinnati, Cincinnati, Ohio.

Enzymes are conductors of energy. Hematoporphyrin in the presence of light energy has a digestive action on the blood proteins, fibrinogen and serum albumin with the production of hydrolytic products. The striking fact is that oxygen is necessary for the proteolytic action of this artificial enzyme.

The Absorption and Excretion of Lead in Primitive Life:—By ROBERT A. KEHOE, University of Cincinnati, Cincinnati, Ohio.

The question of the presence of lead as a normal constituent of living organisms has been investigated in a study of certain primitive agricultural communities. The general methods of study and the results obtained are presented briefly.

Photographs of the experimental subjects and their environment are used to illustrate the primitive character of the communities.

Vaccine in the Prevention of the Common Cold:—By W. E. BROWN, M. D., University of Cincinnati, Cincinnati, Ohio.

An experimental study was made to determine the effects of vaccination on the incidence and duration of common colds. Eighty medical students were vaccinated with a prepared, partially detoxicated vaccine and eighty-two medical students acted as controls. In order to have other evidence of immunity beside clinical manifestations three sets of skin tests were made on the experimental group, using heat killed antigens made from the organisms used in the vaccine. The first set of skin tests was carried out before vaccination, the second set was done thirty days after vaccination and the third set six months after vaccination. All tests were carefully checked and reactions were recorded as sensitive or non-sensitive.

Twelve daily inoculations (subcutaneous) with a partially detoxicated vaccine containing fifteen organisms recovered from respiratory secretions were given to the experimental group. Analysis of the two groups showed them to be comparable except that the control group had had a longer period of local residence and used cigarettes to a greater extent while the experimental group showed a greater incidence of sore throats, sinusitis and chronic coryza during the previous year as well as an alleged greater incidence of common colds with longer duration during the previous year.

The first set of skin tests showed thirty-three per cent non-sensitive to the antigens as a whole, while the reactions to the first dose of vaccine showed thirty-five per cent non-sensitive. The experimental group showed an increased sensitivity up until the 11th dose of vaccine, this being confirmed by the greater incidence and longer duration of colds in the experimental group, as compared with the control group, during the period of vaccination. Reactions to the 12th dose of vaccine indicated 55% non-sensitive, suggesting that sufficient vaccine had not been given. The mean dosage of vaccine was 2.23 cc. with five individuals having a single systemic reaction. The increase in dosage of the vaccine was too rapid for the group as a whole. The second set of skin

tests showed a combined percentage of 68% non-sensitive, thirteen per cent more than was shown by the final vaccine reactions. This may be explained by the development of immunity on the part of some individuals during the thirty days between the time of final vaccinations and the skin tests. The gain in the combined percentage of the non-sensitive as brought out by the second set of skin tests was thirty-five per cent. In the experimental group during the period of the experiment there was a mean number of colds of 1.85 with a mean duration of 7.4 days as compared with 2.17 and a mean duration of 7.6 days for the control group. This is not mathematically significant.

A twenty-five per cent loss of immunity acquired by vaccination was found in the experimental group six months after vaccination, as indicated by the third set of skin tests. Personal impressions of benefits derived from vaccination implied much better results than the actual figures justified. The higher degree of susceptibility to respiratory infections on the part of the experimental group must be considered, but cannot be evaluated mathematically.

The statistical results of the experiment show little, if any improvement as regards common colds in the experimental group as a whole compared with the control group. Individuals in the experimental group appear to have received some benefit. This is in accord with the findings that the group as a whole was not completely desensitized to the particular antigens used. Better results may be possible with an increased dosage of the vaccine.

On the Treatment of Tularemia with a Specific Antiserum:—By LEE FOSHAY, M. D., Christ Hospital Institute for Medical Research, Cincinnati, Ohio.

A specific antiserum has been prepared from the goat after immunization of the animal by subcutaneous injections of formaldehyde-killed suspensions of *Pasteurella tularensis*. This antiserum has proved to be of great benefit in the treatment of human tularemia, causing prompt recession of most of the clinical signs and symptoms, greatly shortening the course of the disease, and preventing suppuration of the involved lymph glands. It must be given early in the course of the infection to yield the best results. When so given the rapidity of clinical cure is quite astonishing.

Evidence is presented to show, at the present stage of development of the serum, that it is not bactericidal and that in amounts relatively far in excess of the satisfactory human dose it will not protect laboratory animals from death by infection with known virulent strains of *P. tularensis*. Its chief therapeutic benefit seems to be associated with its capacity to abolish the state of hypersensitivity that tularemic infection causes in man. The experience with it, in the first series of fifteen human cases, is presented.

The Metabolism of a Woman 106 Years Old:—By J. R. MATSON AND F. A. HITCHCOCK, Ohio State University, Columbus, Ohio.

A series of basal metabolism tests have been run on Mrs. Anna Burns, aged 106 years, a patient at St. Anthony's Hospital, Columbus,

Ohio. Her weight is 31.81 kilos and height is 147 cm. Blood pressure ranges between 170–90 and 140–80, pulse varies from 66 to 72. Arteries are sclerotic and her temperature subnormal. Blood sugar is low, 66 mg. per 100 cc. Wasserman is negative. Blood count and urinalyses showed nothing of significance. Body surface determined by the linear formula of DuBois was 1.13 sq. m.

Six tests made on the Benedict Roth apparatus gave the following averages: Tital air = 206.4 cc.; oxygen consumption = 81.0 cc. per minute; total calories per hour = 23.91; calories per hour sq. m. body surface = 21.16.

Average calories from food consumed was 919, an excess of 60% over 574, the basal requirement.

The table of normal standards does not extend beyond 80 years. The accepted figure for women of 80 is 33 cal. per hour per sq. m. of body surface. The results obtained on Mrs. Burns were 36% below this figure. For the 25 years of life between 55 and 80 the basal metabolism drops 12%. The results of this investigation indicate that the basal metabolism drops at an increasing rapid rate after the age of 80 is passed.

The Effects of Small Quantities of Ethyl Alcohol on the Respiratory Exchanges during Rest, Work and Recovery:—By ROBERT C. GRUBBS AND F. A. HITCHCOCK, Ohio State University, Columbus, Ohio.

This series of experiments has been carried out with a view of determining whether or not the energy derived from the oxidation of alcohol can be used by the muscles in doing work. Three male subjects were used and the respiratory exchanges were measured in basal and work tests. Control and alcohol tests were run alternately. In alcohol tests the subjects took 95% alcohol in quantities from 15 to 30 cc. diluted to 200 cc. with tap water. In control tests, 200 cc. of tap water were usually taken. The alcohol produced a significant lowering of the respiratory quotient both in basal and work tests. The oxidation of alcohol which was attributed to muscular work was calculated from the lowering of the non-protein respiratory quotient in the work tests. From the results obtained the authors conclude that the alcohol can be used in the performing of muscular work.

Acceleration of the Ulcer Producing Action of the Bile Salts:—By L. H. SCHMIDT, University of Cincinnati, Cincinnati, Ohio.

Feeding of thyroxin increases the susceptibility of guinea pigs to the ulcer producing action of the bile salts. This increased susceptibility is proportional to the amount of thyroxin administered. Experiments on the effect of thyroxin feeding on the blood and tissue phospholipids of the rabbit suggested that the increased susceptibility is due to a decrease in the phospholipid content of the blood and certain tissues. This suggestion is supported by the fact that the amount of phospholipid required to protect the thyroxin fed animal is two and one half times as great as the amount required to protect the normal animal from the same dose of bile salt. Diphtheria toxin

also increases an animal's susceptibility to bile salt ulcer—the facts indicate that the mechanism has points of similarity.

Ulcers produced by bile salt injection, alone, or following thyroid or diphtheria toxin treatment are much too acute to bear any striking resemblance to the acute human gastric ulcer. These ulcers never occur unless the treatment is so severe as to kill the animal. Recent experiments have shown that the combination of very small doses of bile salt with oleic or stearic acid results in the production of gastric ulcer, without producing death. This ulcer is practically identical with the human acute ulcer. It is produced by one-fourth of the amount of bile salt required to produce ulcer alone, plus an equal amount of oleic or stearic acid. Twenty times the quantity of oleic acid used will not produce ulcer if injected alone. The possible significance of these facts in the production of human gastric ulcer is discussed.

Child Labor in the United States as Subjected to Poisons and Dusts:—By EMERY R. HAYHURST, Ohio State University, Columbus, Ohio.

A fact-finding inquiry into gainful employments of minors under 18 years of age exposing them to poisons and dusts. States showing chief concentrations; their laws; occupational diseases found. Present day trends. Evidence that minors are more susceptible than adults to poisons and dusts.

Data on Ventilation Conditions—A Field Neglected by the Physician (with demonstration of essential aerological determinations):—By EMERY R. HAYHURST, Ohio State University, Columbus, Ohio.

Summary of effects of room air conditions on physiological reactions. Evidence that American physicians neglect this subject in practice and research. Gold brick ventilation and air conditioning schemes. Protocols of some aerological determinations in various types of interiors. (Demonstration of essential instruments and methods).

Central Connections of the Eighth Cranial Nerve in the Guinea Pig:—By RUSH ELLIOTT, Ohio University, Athens, Ohio.

This report involves only the cochlear portion of the eighth nerve. Neurons begin in the cochlea, their cells of origin being in the spiral ganglion, and enter the brain at the junction of the medulla and pons, terminating in the dorsal and ventral cochlear nuclei. From these two nuclei secondary neurons pass dorsally and then ventromedially, forming the acoustic stria which separates into a lateral portion which joins the lateral lemniscus of the same side and a medial portion to join the lateral lemniscus of the opposite side. From the ventral nucleus arise fibers which follow a ventral superficial course, forming the trapezoid body, and decussating to join the lateral lemniscus and superior olivary nucleus of the opposite side. From the superior olive the olivary peduncle fibers synapse with the nucleus of sixth cranial nerve and join the median longitudinal fasciculus.

The lateral lemniscus carries on rostrally, many of the fibers synapsing along the course of the tract, the cell bodies of the neurons of the next higher order forming the nucleus of the lateral lemniscus. At the level of the inferior colliculus part of the fibers of the lemniscus terminate in the colliculus, while others with neurons which originate in the colliculus pass to the medial geniculate body, forming the brachium of the inferior colliculus.

Decomposition Products of Chlorophyll in a Herbivorous Animal and the Relationship of these Products to Haemin:—By PAUL ROTHEMUND, Antioch College, Yellow Springs, Ohio.

The C. F. Kettering Foundation for the study of chlorophyll and photosynthesis at Antioch College, Yellow Springs, Ohio, is especially interested in chlorophyll decomposition products occurring under normal physiological conditions. One of these products is the phylloerythrin in the bile and feces of herbivorous animals. The place of formation of this porphyrin was unknown to date. An investigation was undertaken with this object in view. The report contained a few aspects of the problem of naturally occurring chlorophyll decomposition products and a discussion of the chemical relationship of these substance to haemin, the red coloring matter of blood. Slides demonstrated the photosensitizing effect of porphyrins in the human and the animal body.

Brief summary of the experimental results of the investigation: Phylloerythrin occurs in the third stomachs of cows and sheep; traces were found spectroscopically in the first stomach. The substance was isolated in crystalline form and identified in the form of the methyl ester. Subcutaneous injection of phylloerythrin into guinea-pigs has a photosensitizing effect on these animals. The occurrence of phylloerythrin as a result of mild chlorophyll decomposition in the cow's stomach supports a formula for chlorophyll containing a five ring system added to the porphin structure.

A few more porphyrins have been found in the stomachs of the cow. Work is in progress to identify these substances.

Teaching Scientific Methods through Activities in Health Education:—By MRS. NORMA SELBERT, College of Medicine, Ohio State University, Columbus, Ohio.

Studies made last year, and also in 1928, to investigate the health habits of University Women, showed up the ineffectiveness of the superficial, abstract, courses in hygiene which have been taught heretofore.

During the past year experiments have been conducted with the intention of making the course entitled Public Health Problems in the Ohio State University practical. The aim has been to connect scientific instruction with conditions under which the student must sleep, eat, work, and play. Special effort has been put forth to teach each student how he can adjust himself to his environment, and how he may change undesirable habits.

Catalogue announcements of this course read as follows:

PUBLIC HEALTH PROBLEMS:—Five credit hours. One Quarter. Autumn. Winter. Spring. Four class periods and one field trip each week. Students provide their own means of conveyance on trips. Prerequisite, Chemistry 401 or 411, Physics 401 or 403, and five credit hours in college biological science; or a background in economics, or sociology, or education, or industrial engineering. A previous or concurrent course in bacteriology is recommended. Instructor: Mrs. Selbert.

A résumé of theories and discoveries pertaining to the causes and prevention of disease. An elementary consideration of the public health aspects of such problems as food supplies, water, sewage, refuse, ventilation, communicable diseases, maternity and infant welfare, housing and school hygiene, camp and rural sanitation, tuberculosis, cancer, goiter, quackery, mental and industrial hygiene, vital statistics, and health administration.

In the onset of each quarter, the instructor discussed various obvious public health problems, and spoke on the History of Public Health Services; and newer positions in the field of public health.

Each student then selected a public health problem which he or she studied throughout the quarter. The following pages were given to each person who registered for the course. (The pages were passed around during the meeting.)

Students were encouraged to create a way of life which enables them to keep the laws of health. To promote maximum and continuous growth was the aim in each personal undertaking. They were led to draw upon all available fields of knowledge and experience and to keep close check upon their own habits. They were led to develop a consistent and comprehensive view of life including facts about birth, marriage, morbidity, and death. They viewed their problems in the light of a mature outlook on life. Each student was asked often to define his, her outlook on life.

Conferences, and frequent association with superior persons, and specialists who excelled in fields concerned with their problems enabled each student to get a superior view of life and exact knowledge on his or her problem without having much organized class work.

The teachers function was to help the student in making appraisals of the knowledge he acquired. Life is the art of knowing what to relinguish and what to hold. The aim was to develop in each student an adequate view of life, to improve his personal health and behavior, to give him accurate knowledge about public health problems.

During the periods given over to hearing reports from investigations—all students in the class learned general facts about all of the problems listed. Each student also learned a lot about the one problem for which he expressed personal interest.

Some Observations on the Relation of Bodily Weight to the Mental Status in Schizophrenia (Dementia Praecox):—By CARL W. SAWYER, M. D., White Oaks Farm, Marion, Ohio.

An analysis is made of 175 cases of Dementia Praecox seen over a

period of twenty-six years and the relation of bodily weight to these cases.

Charts and diagrams were used to illustrate the facts as follows:

1. There is a decided shifting of weight in Dementia Praecox cases from the highest weight attained to the lowest reached. This is most pronounced in the one to eighteen pound range.

2. There is a decided shifting of weight in Dementia Praecox cases from the weight upon admission to the weight upon discharge. The most common range is from one to seventeen pounds. This range may be either a gain or a loss.

3. Recovery and improvement in Dementia Praecox cases is very definitely associated with a gain in weight. Conversely a patient who gains weight has over twice as many chances of recovering as one who does not and they have about four times greater chances of being improved than if they do not gain weight.

4. Dementia Praecox cases show an immature development so far as their weight is concerned.

5. The commonly accepted theoretical weight tables cannot be used as guides in determining the normal weights of Dementia Praecox patients.

6. Whether a Dementia Praecox case recovers or not does not depend upon the relation of their actual weight to their theoretical weight.

7. Decided loss of weight below the theoretical weight is of no significance so far as the beneficial outcome of the patient is concerned.

8. There is a definite relation between bodily weight and mental status in cases of Dementia Praecox; the mental status improves practically always with an increase of bodily weight.

The Effect of Various Salts and the Hydrogen Ion Concentration on the Length of Life of Asellus sp.—By E. ROWLES AND P. S. SHURRAGER, Ohio University, Athens, Ohio.

EXPERIMENTAL PROCEDURE.

1. Asellus were collected and brought into the laboratory conditions twenty-four hours before the experiments.

2. Stender dishes of 25 cc. volume, with ground glass lids were used.

3. Three males and three females were placed in K, Ca, Mg, and Na, of M/8, M/16, M/40, and M/80 concentrations.

4. Three males and three females were placed in a pH range of 2.97 to 8.55.

5. Experiments were observed on the antagonistic effects of these salts.

6. Controls were kept in distilled, tap, and pond water.

7. The Asellus were observed constantly until death, at which time they were removed from the solutions, dried on filter paper and weighed.

EXPERIMENTAL RESULTS.

1. The relative toxicity of the ions in the four concentrations used, showed: K > Ca > Mg > Na.
2. Within the male or the females, the lethal effect of the salts is inversely proportional to the weight.
3. Females died more readily than males in January; while the males died more readily than the females in March.
4. Asellus showed a tendency to live longer in the higher pH.

Blood Changes in Emotionally Excited Rabbits:—By L. B. NICE AND H. L. KATZ, Ohio State University, Columbus, Ohio.

A chemical analysis of the blood of quiet and excited rabbits was undertaken to determine the contributing factors in the specific gravity increase of excited blood.

The blood samples were taken directly from the heart of 24-hour-fasting rabbits. Excitation was produced by stimulation with Faradic currents for a period of about five minutes by means of a Harvard inductorium. The excited sample was drawn approximately 10 minutes after the excitatory period.

The constituents analyzed were: sugar, non-protein nitrogen, urea nitrogen, preformed creatinine, total creatinine, and uric acid (Folin-Wu); calcium (Roe-Kahn), inorganic phosphorus (Youngburg and Youngburg), chloride (Whitehorn), cholesterol (Day and Bollinger), hemoglobin (Newcomer).

The results on ten normal rabbits average as follows: Sugar, 18% increase; non-protein nitrogen, 16.4% increase; urea, 18.3% increase; preformed creatinine, 25% increase; total creatinine, 10.1% increase; uric acid, 51% increase; inorganic phosphorus, 22.2% decrease; calcium, no change; chloride (as NaCl) 6.3% increase; cholesterol, 12.2% increase; hemoglobin, 6.3% increase.

The results indicate that (1) practically all of the common blood constituents (with the exception of calcium and phosphorus) contribute to the specific gravity increase of blood of excited rabbits; and (2) there is a great catabolic action upon protein metabolism as well as carbohydrate metabolism during emotional excitement.

The Behavior and Autopsy Findings in a Case of Cerebellar Agenesis in a Dog:—By GRANT O. GRAVES, Ohio State University, Columbus, Ohio; introduced by Dr. F. L. Landacre.

A seven months old dog, of a normal litter, was described which presented asynergic movements on land (atonia, asthenia, ataxia and hypermetria) and synergic movements in the water (normal swimming). Motion pictures were shown to illustrate the attempts to rise, to walk and to swim. Autopsy photographs were shown illustrating the absence of the vermis and the diminutive cerebellar hemispheres. The relative distribution of the pyramidal tract to the segments of the spinal cord was suggested as a possible explanation for the strength of the neck and trunk and weakness of both extremities, when the cerebellum is not present and the remaining physiological levels are functioning.

E. THE SECTION OF PSYCHOLOGY.

PROF. HORACE B. ENGLISH, Ohio State University, Columbus, Ohio, *Vice-President.*

(Abstracts not submitted.)

F. THE SECTION OF THE PHYSICAL SCIENCES.

PROF. FORREST G. TUCKER, Oberlin College, Oberlin, Ohio, *Vice-President.*

Final Revision of the Crystal Structures Present in Certain Chromium-Nickel Alloys:—By JAMES O. LORD AND F. C. BLAKE, Ohio State University, Columbus, Ohio.

When chromium is dissolved in nickel the nickel lattice is distorted from a face centered cube of edge 3.516 àngstroms to one of edge 3.603 angstroms at a weight per cent of chromium of sixty, the amount of the distortion being 2.5 per cent.

When nickel is dissolved in chromium the body-centered lattice is slightly reduced in size, but not more than 12 weight per cent of nickel is soluble. For alloys richer in chromium than sixty per cent, new phases show up and by proper etching with a twenty per cent solution of sulphuric acid and by examining the insoluble residue two new phases are sorted out, one a face-centered cubic lattice NiCr having 96 atoms to the unit cell, 48 chromium and 48 nickel, with the length of the edge 10.62 ängstroms, practically just three times that of the undistorted nickel lattice. The other phase is body-centered tetragonal Ni_2Cr with 8 atoms of nickel and four atoms of chromium, the a-edge of the tetragonal prism being 5.31 ängstroms, with the axial ratio 0.92. The space group of the new cubic lattice is T^3_h and of the tetragonal lattice C^5_{4h}.

In the micro-photographs of these alloys rich in chromium only three phases could be clearly distinguished, though one of the three showed lines or striations through it in such a way as to make it possible to say that it was really two phases.

The possibility of a fifth phase, chromium nitride, being present in certain melts was discussed.

An Exact Determination of the Ratio of the Edges of the Unit Lattices of Calcite and Rock Salt:—By F. C. BLAKE AND E. W. FORD, Ohio State University, Columbus, Ohio.

A large number of powder photographs of rock salt and calcite with three cameras of radii 11.3, 16.5, 30.5 cms. were taken, the rock salt and calcite being kept separate in one series of measurements and intimately mixed in the other series. For proper determination of the Miller indices of the faces of the 46° rhomb of calcite rotating crystal photographs of calcite were taken.

Attempts were made to weight the a-values according to the intensity and sharpness of the lines on the powder photographs.

Taking the edge of the rock-salt cube as 5.62800 ångstroms, that of the calcite rhomb was found to be 6.3584 ± 0.0003 in the first series of measurements and in the series intimately mixed it came out 6.3598 ± 0.0006. A critical discussion of correction factors was presented. No correction factors were used in the series where the two powders were intimately mixed. This indicated that there is a small systematic source of error in the method of applying correction factors which is being given further attention.

Laue Photographs of Piezoelectrically Oscillating Quartz Crystals:—By CARL E. HOWE, Oberlin College, Oberlin, Ohio.

Laue spots from piezoelectrically oscillating quartz crystals have a fine structure, indicating increased reflecting power from point to point within the crystal, and caused by inhomogeneous strains present. Using a point focal spot and collimating slits large enough to cover the entire width (28 mm.) of a crystal, Laue "slit" photographs have been made, revealing the inhomogenous strains present in that particular cross-section of the crystal. For cases of simple resonance modes of vibration there is a one to one correspondence between the strains thus revealed and the lycopodium powder diagram of the same mode of vibration.

The Use of the F. P.–54 Pliotron in the Measurement of X-Ray Absorption Coefficients.—J. E. EDWARDS, Ohio University, Athens, Ohio.

The F. P.–54 Pliotron Vacuum tube has been used successfully in amplifying and measuring ionization currents on an X-ray spectrometer in connection with the measurement of absorption coefficients. Extreme precautions in shielding were necessary, the tube being mounted on the spectrometer arm with the ionization chamber. Absorption coefficients of Al and Cu measured from .25 A to .6 A were in agreement with the data of Allen and Richtmyer.

Radiation Attending Low Critical Potentials in Hg and An Electro-Static Method of Narrowing Electron Velocity Distribution:—By E. N. SHAWHAN, Ohio Wesleyan University, Delaware, Ohio.

A search was made for possible radiation corresponding to critical potentials below 4.66 volts found by Professor Jarvis and verified by Pavlov and Sueva. The three-element type tube was used with the grid and plate connected. The ultra-violet and visible regions were photographed with a Hilger E-3 quartz spectrograph. Using a pyrex window the red and infra-red regions were investigated with a fast glass spectrograph and with a Bausch and Lomb constant deviation spectrograph. Eastman type P and type Q plates were used. No radiation at potentials less than 4.9 volts has been found to date.

Electron velocity distribution was reduced by requiring a unidirectional beam of electrons to travel against a certain retarding field while being accelerated at right angles to their initial direction by a suitable field. An initial distribution of about 1.5 volts was reduced to less than 0.4 volts.

Stabilization of Oscillators Used to Drive Quartz Crystals:—By D. W. BOWLAND, Oberlin College, Oberlin, Ohio.

In making Laue photographs of a piezo-electrically vibrating quartz plate it was desired to drive the crystal at one of its many resonance modes of vibration, where the crystal does not have sufficient stabilizing reaction upon the driving oscillator circuit. A means was devised to synchronize the frequency of the oscillator with the resonance frequency of the crystal. The deviation of the crystal current at the resonance point was recorded on a potentiometer-controller which operated a motor-driven vernier condenser in the oscillator circuit. The frequencies were synchronized to within fifty parts in a million without temperature control.

Heat of Vaporization and Charles' Law Apparatus for First Year College Physics:—By C. W. JARVIS, Ohio Wesleyan University, Delaware, Ohio.

1. Apparatus for heat of vaporization was described in which the Bertholet design was modified by adding a super-heating coil and a new design of steam trap, eliminating loss by evaporation. Results within 5 calories of the accepted value are readily obtained.

2. A Charles' Law apparatus was shown by lantern slide, having the following features:

(1) All glass parts in contact with mercury, insuring long life without recleaning.
(2) Small amount of mercury used.
(3) Self-draining air chamber.
(4) Sensitive control for adjustment of air to constant volume.
(5) Capillary correction eliminated for pressure measurement.

A Simple Curved Mica X-Ray Spectrograph:—By J. F. HAINES, Oberlin College, Oberlin, Ohio.

A wood cylinder of 2 cm. radius about which is bent a strip of mica .036 mm. thick is mounted with its axis parallel to the slit system. The rays from a Mo tube come through the lead slits, fall on the mica at grazing angle, and after reflection strike two parallel plates so mounted that half the beam falls on the first plate and half on the second, 56 mm. behind it. This gives a simple and accurate means of measuring $\tan 2\theta$, and hence $\sin \theta$ to be used in Bragg's equation, $\lambda = \frac{2d \sin \theta}{N}$.

Fifth order spectra showing α_1, α_2, β, and γ, lines of the K series can be obtained in about two and one-half hours, running the tube at 27 KV and 18 milli-amps.

Values of λ measured by this method are found to be accurate to well within one percent.

The Use of the Milling Machine as a Precision Optical Bench:—By J. J. JOHNSON AND C. W. JARVIS, Ohio Wesleyan University, Delaware, Ohio.

A milling machine, because of its many adjustments and accurately controlled and measured motions, was found to serve admirably as a

base for an optical bench upon which measurements of considerable precision may be made. A wooden extension arm carrying the light source and collimator was fastened to one end of the bed of the machine in a manner such that it might be removed easily when the machine was needed for other purposes. The lens system to be tested was placed near the center of the bed.

Focal lengths may be determined readily by the modification of the general magnification method which calls for a measured change in the object distance, as this distance can be measured very accurately by the longitudinal screw-motion of the bench.

When the machine is used as a nodal slide, the light source must of course be mounted independently of the rotating bed. The image screen is suspended by clamps from the upper axle.

The bench was found to be ideal for measurement of short focal lengths by displacement; for nodal slide work and the determination of cardinal points; for focal lengths by magnification methods; and for aberration work.

The Raman Spectra of a Series of Organic Chlorides:—By R. R. HAUN, Ashland College, Ashland, Ohio.

When light from some intense source, preferably monochromatic or containing as few frequencies as possible, is passed into various substances, the light scattered by the substance is found, on analysis with the spectrograph, to contain additional frequencies to those present in the original source. The displacements of these frequencies from the original frequencies are characteristic of the substance and are known as the Raman spectrum of the substance.

These displaced frequencies are due to the addition or subtraction of energy from the light quantum by the molecule and consequently indicate the energy levels of the molecule under normal conditions. These energy values are assigned to the motions of the atoms with respect to each other, since the same pair of atoms always produce the same displacement in different compounds. From the energy values the force of attraction between the atoms in the molecule may be calculated.

The value for the carbon-chlorine bond is 657 cm^{-1} in all organic chlorides where the chlorine atom is attached to the carbon atom at the end of the chain of atoms, no matter how long the chain. If the chlorine atom is attached to a carbon next to the end, the value is reduced to a little more than 600 cm^{-1}. When the chlorine is attached to a carbon to which two other chains of atoms are attached, the value of the displacement is still further reduced to 564 cm^{-1}. In general one or two lower and weaker frequencies may be associated with this bond, but they are not as consistent nor nearly as strong as the fundamental.

Zeeman Effect Observations:—By RALPH A. LORING, Ohio State University, Columbus, Ohio.

The apparatus set up recently at Mendenhall Laboratory for Zeeman Effect is described. It consists of a large Weiss type water

cooled magnet having an exciting current of 114,000 ampere turns and with ferro-cobalt pole tips, the faces of which are 10 mms. in diameter. The field obtained is 40,400 gauss with a gap of about 4 mms. The spectroscopic apparatus consists of a 30,000 line per inch Wood 21 ft. concave grating set up in the Paschen Runge arrangement. The dispersion and resolving power are about 1.32 AU per mm. and 70,000 respectively in the first order. Pictures of various typical Zeeman effects are shown. Of particular interest are Pb 4798, 4761, 3854, 3689. These form an SP multiplet in the third spectrum. The coupling is J-J type.

Factors Affecting the Constancy of Frequency of the Negative Resistance Tetrode Oscillator:—By W. C. SEARS, Ohio State University, Columbus, Ohio.

Interest has recently been renewed in the Dynatron oscillator principle, since it has been found to have excellent frequency stability characteristics. Consequently, it is being widely used as a convenient variable frequency standard.

The Dynatron offers negative resistance by virtue of the secondary electrons emitted from the plate due to its bombardment by the primary electrons from the filament. A tube operating over a negative resistance characteristic will sustain oscillations when connected in parallel with a tuned circuit, if $r \leq L/RC$; where, r is the absolute value of the negative resistance; L, the inductance; R, the resistance of the tuned circuit, and C, the capacity.

Experimental data was taken and graphs plotted to show the dependence of frequency upon operating voltages. The inductance and capacity being held constant, filament, screen-grid, control-grid and plate voltages were varied separately, and the corresponding frequency change measured by the audible beat method, using a standard tuned-grid oscillator. The frequency is practically independent of operating voltages for the UX-322 tube, if the screen-grid is held at a high positive value (85 ± 2 volts), the filament at 3.3 volts (rated), the control-grid as highly negative as will sustain oscillations; under these conditions, the plate voltage is not critical. Thus, a variation of 0.1 volt in the control-grid, screen-grid and filament voltages, each results in a frequency variation of .007, .004, .005 cycles respectively. The frequency change corresponding to a 10-volt plate variation is very nearly zero. Such constancy of frequency compares quite favorably with that of a crystal controlled oscillator.

A. W. Hull developed an expression for the frequency,

$$f = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \left(\frac{R}{2L} - \frac{1}{2rC}\right)^2}$$

assuming that the negative resistance was constant; i. e., a linear negative characteristic. This is not justified as shown by static and oscillatory, Ep-Ip, characteristics—the latter exhibiting a hump symmetrically in the center. Also, the frequency changes when the negative resistance is apparently constant.

Probably, high harmonics are present and the theoretical explanation of the frequency variation is quite complex.

Dynamial Stability of the Stars:—By HERMAN ROTH, Ohio State University, Columbus, Ohio.

The final test of any stellar model is its stability. The question whether or not the star will maintain its configuration in spite of the many perturbations that are occurring constantly is of primary importance. The general condition for the dynamical stability of any state of a configuration is that the energy of the state shall be a minimum. The method generally used, is to introduce an arbitrary varied motion, constrained in a particular way and determine if the perturbation increases or decreases the energy of the state. If the energy decreases, the state is unstable. If, however, the energy increases, the state may or may not be stable. It is only stable for this particular perturbation. There may be others for which the state is unstable.

The Jacobi Condition for dynamical stability of a configuration shows the state unequivocably stable or unstable. It is not always easy to apply because it requires a complete solution of the equilibrium equations. The procedure followed in the use of this condition was explained by an application to a star considered as a slowly contracting or expanding fluid sphere.

Determination of Natural Frequency of Weight Attached to Vertical Spring:—By THEO. F. KUECHLE, Central High School, Columbus, Ohio.

A weight of "W" lbs. is attached to a spring, "S," and produces a stretch of "h" inches at the bottom end of the spring as measured from the natural or unloaded position of the spring. If the weight be pulled down another "h" inches and then released, the system will vibrate at a rate dependent entirely upon the extension "h."

The energy transformations which occur as the vibration goes through a complete cycle have been tabulated below.

Since no energy is added or lost during any given vibration, it follows that the energy is constant at all points of the vertical vibration. This gives us the value of the kinetic energy of the weight, "W" when it is passing through the center of its stroke at an unknown velocity, "V." However, knowing now that its kinetic energy is $\frac{Wh}{2}$, which equals $\frac{WV^2_m}{2g}$, where V_m is the maximum velocity of W in feet per sec., h in feet, and $g = 32.2$ feet/sec./cec.

Since the motion is harmonic a definite relation holds between the average velocity, Vav, and the maximum velocity, Vm., viz., Vav = .636 Vm, the factor .636 being obtained by averaging the values of "y" of the function $y = \sin \alpha$ during a 90° interval as limiting values of α.

Position of Spring Supported Weight	Weight		Spring		Total Energy
	Kinetic	Potential	Kinetic	Potential	
Top	0	2 wh	0	0	2 wh
Center . .	$? = \frac{Wh}{2}$	wh	0	wh ÷ 2	2 wh
Bottom. . . .	0	0	0	$2h\ \frac{(2\,W + 0)}{2} = 2wh$	2 wh

Evaluating the equation $\frac{Wh}{2} = \frac{W\,V^2_m}{2g}$ we have $V^2_m = gh$, or $Vav = .636\ V_m$ from which $Vav = .636\sqrt{gh}$.

In general: distance $= \begin{cases}\text{average} \\ \text{veloc.} \times \text{time.}\end{cases}$ Since it is more convenient to count only the stroke when "W" hits bottom, the distance traveled in one minute by weight W equals 4hf where f = number of complete vibrations per minute.

From the equation $\left\{\begin{array}{rcl} 4hf & = & .636\sqrt{gh} \times 1 \text{ minute} \times \\ \text{Distance} & = & \text{av. veloc.} \times \text{time} \end{array}\right\} 60$

Since it is more convenient to measure "h" in inches the above reduces to $\frac{4\,h''\,f}{12} = .636\sqrt{g\,\frac{h''}{12}} \times 60$ from which $f = \frac{12 \times .636}{4\,h''}\sqrt{32.2 \times \frac{h''}{12}} \times 60$ which simplifies into $f = \frac{187.7}{\sqrt{h''}}$ double strokes per minute.

This equation of natural frequency holds good only if the weight of the spring is negligible compared to the weight at the bottom of the spring; otherwise the extension "h" must be increased by an amount in proportion to the stretch produced by the weight "W."

The original mathematical work preceding the experimental verification was made by me October 6th, 1925. Other vibrating mechanical systems have been investigated mathematically and experimentally with the same satisfactory results.

The entire series of investigations was inspired by the desire to give the boys of high school age an easily verified prediction and mechanical analogy of what occurs when a charged electrical condenser is placed across an inductance. The frequency of the resulting oscillations will be given by the formula $f = \frac{1}{2\pi\sqrt{LC}}$, where L = self-inductance in henries and C capacity of condenser in farads. The resistance of the oscillating circuit is neglected.

G. THE SECTION OF GEOGRAPHY.

PROF. EUGENE VAN CLEEF, Ohio State University, Columbus, Ohio, *Vice-President.*

The Prairie Peninsula:—By EDGAR NELSON TRANSEAU, Ohio State University, Columbus, Ohio.

The causes of the Tall Grass Prairie and "Prairie Peninsula" continue to be debated as if the only problem involved is grassland vs. forest, and that the answer has but two alternatives: climate or soil. As a matter of fact when an adequate discussion of the prairie is published it must account for the natural geographic boundaries of certain tree species, the occurrence of prairie species and prairie colonies far distant from the main body of the prairie, the dominance of grasses on both well drained and poorly drained areas, the nature of the forests bordering the prairies, the fact that this prairie dominance is not recent but has persisted for 20 to 30 centuries, that unique types of soil "prairyerths," have developed, that there is no consistent correlation between prairies and soil types as classified by modern pedologists, and that at the time of settlement prairie occupied more than 300,000 sq. mi. of land surface stretching from Manitoba to the Gulf, and from Nebraska to Ohio.

In explaining the Tall Grass Prairies, climate cannot be dismissed by repeating the tradition that they "developed in a forest climate" when weather statistics do show difference in relative humidity and precipitation types. Growth of trees on former wet prairies is no proof that they could grow there a century ago. The post glacial history of the prairie peninsula is certainly different from that of the forested regions north, south and east.

The prairie problem is a highly complex one, and its solutions will involve a large group of contributing factors of the present and the geologically recent past.

Some Experiences in Teaching Geography by Radio:—By W. R. McCONNELL, Miami University, Oxford, Ohio.

For the past two years I have broadcasted lessons in Geography each Thursday afternoon from Station WLW in Cincinnati. The length of time allotted to each lesson is twenty minutes.

There are difficulties in the way of getting satisfactory results. In the first place, education is achieved by self-activity and there is a tendency for pupils to remain passive during a radio lesson. This tendency is recognized and a conscious effort made to overcome it by: (1) placing an outline of the lesson together with questions and problems in the hands of the pupils; (2) making constant references to maps during the lesson.

The radio can supplement the classroom teacher; it can never be a substitute for her. A radio lesson cannot be built to fit in with the needs and capacities of each child. The adaptation of the material presented to the individuals in the class will always be the peculiar work of the teacher.

From time to time teachers have indicated definite benefits that have accrued from the radio lessons. Among the benefits listed most frequently are:

1. The habit of attentive listening.
2. Good drill in the taking of notes.
3. The power to distinguish between the facts that are important in showing human relationships and facts that are merely interesting.
4. The writing out of notes which affords a fine opportunity to correlate with English.
5. The preparation of graphs and the ability to interpret graphs.

Letters received from home listeners in many states indicate a genuine interest in geography on the part of adult America. An analysis of the comments received from adult listeners indicates a much keener interest in the story of human adjustments to the natural world than in the mere listing of facts about countries.

Notes on the Vegetation of Ireland with Special Reference to the Limiting Factors of Geographical Distribution:—By A. E. Waller, Ohio State University, Columbus, Ohio.

A statistical study of the plant life of Ireland shows that while the majority of plants are those of England and Wales that two groups notably one from North America and one from the Mediterranean region are absent from the English flora. The peculiar local distributions of plants are the result of complex factors involving topography, moisture, evaporation, etc. Among the introduced plants certain palms, bamboos, Fuschia and other tender woody plants thrive while wheat and maize do not. The theory of limiting factors as opposed to geographical barriers is discussed in attempting to account for the peculiarities of the distributional problems.

The Influence of the Charcoal Iron Industry in Southern Ohio:—By Wilber Stout, Ohio State University, Columbus, Ohio.

The Hanging Rock Iron District embraced an area of approximately 120 square miles with 24 charcoal furnaces in Greenup, Carter, and Boyd counties, Kentucky, and 170 square miles with 45 stacks in Lawrence, Scioto, Gallia, Jackson, Vinton, and Hocking counties, Ohio. The industry here was inaugurated with the building of Argillite Furnace in 1818, and ended with the abandonment of Jefferson in 1917. The period of greatest activity was from 1832 to 1870, during which time both furnace building and operation were vigorously prosecuted. At the time it ranked as one of the most important iron centers of the world. Both capital and labor were attracted to the region. These furnaces were rather uniformly distributed over the area from 3 to 5 miles apart as each required ore and timber holdings of 5,000 to 10,000 acres. The requirements for the operation of a charcoal furnace were 100 men and 50 yoke of oxen. The labor consisted in cutting and coaling the wood, mining the ore and limestone, smelting the stock, and hauling the iron to the place of shipment. The furnaces were a powerful factor in the development of industries in the Ohio Valley, in the promotion of trade, in the strengthening of river traffic, in the

projection of railroads into the area, and in the rapid development of the region as a whole.

Soil Development in Ohio.—By G. W. CONREY, Ohio Agricultural Experiment Station, Wooster, Ohio.

Soil development is an expression of the effect of environment under which soil material has existed. Where soils have existed in place under fairly good drainage for a sufficient length of time for the environmental conditions to be impressed there is developed in the soil a differentiation into layers or horizons with markedly different characteristics. Such a soil is a *mature* soil. Where, as a result of unfavorable conditions, such as a high water table, or of erosion, there is little differentiation into horizons, the soil can be called *immature*. Recently deposited materials, such as stream alluvium, show little or no development of horizons or layers. These are *youthful* soils.

The soils of Ohio have developed under a humid climate, and with a deciduous forest cover. The mature soils developed under these conditions have been designated grayish-brown forest soils. Differences in topography and drainage in any area have resulted in marked differences in the stage of soil development. As a result soils may range in color from brown, through grayish-brown and gray to grayish-black.

Although all of the mature soils of the state have many characteristics in common, variations in parent material are reflected in the soil derived from them, as is shown in the marked difference in the glacial limestone and glacial sandstone and shale soils. Time of development is important as is shown in the nature of the soil derived from the Late Wisconsin drift in western Ohio, and from the Illinoian drift in southwestern Ohio. Both are derived from calcareous glacial drift, but in one case the depth of leaching is from 2 to 3 feet, in the other 8 to 10 feet.

Factors Explaining Ohio's Freak Winter in 1932:—By PARIS B. STOCKDALE, Ohio State University, Columbus, Ohio.

The weather of Ohio during the early months of 1932 was history-making because of two exceptional conditions: (1) the abnormal warmth of January and February; and (2) the abnormal cold of March, especially the first half when a phenomenal, prolonged cold wave visited the state. January was the warmest January on record, with an average state temperature for the month 12.1 degrees above normal. The next month was the warmest February on record, excepting 1890 and 1930. The departure from the normal temperature was plus 8.8 degrees. Winds from the south and southwest prevailed. North and northwest winds were scarce. For the whole month of March the temperature for the state averaged 4.9 degrees below normal. During the first half of the month the departure was much greater. During the prolonged cold wave, which lasted ten consecutive days between March 6 and 10, inclusive, the minimum daily temperatures were lower than during all of the preceding days of the winter, with few exceptions. At Columbus, during the cold wave, minimum daily

temperatures ranged between 5 and 20 degrees above zero. During the months of December, January, and February, there were but two days with lowest temperature below 20 degrees, at Columbus. Conversely, there were no March days as warm as the warmest days of the earlier winter months.

The immediate explanation of Ohio's freak weather of early 1932 lies in the behavior of the anticyclones ("highs") and cyclones ("lows"). The courses of these "storms" were plotted and studied. The performance of the cyclones and anticyclones during January and February was exceptional in these respects: (1) most of the "lows" passed to the north of the state, thus causing a sweep of air from a southerly direction; (2) "highs" did not come from the cold northwest and pass within influencing distances of Ohio; instead, many "highs" came from the west and southwest and swept across the continent to the south of Ohio, thus causing a sweep of warm air across the state from the south; (3) several highs loitered over southeastern United States to aid the prolonged periods of warm weather. During the ten-day cold wave of March, the anticyclone-cyclone relationships were the reverse of those of most of the earlier winter. A cold "high" came into the United States at the northwest, carrying temperatures as low as 20 degrees below zero. This anticyclone loitered over western United States for several days and compelled a sweep of cold west and northwest winds across Ohio. No explanation is attempted for the cause of the peculiar behavior of the cyclones and anticyclones during Ohio's freak winter of 1932.

Washington's Lands in Ohio:—By Guy-Harold Smith, Ohio State University, Columbus, Ohio.

George Washington owned in the State of Ohio three tracts of land located in the present Clermont and Hamilton Counties. These three areas, totaling 3,051 acres were surveyed in 1788 and title was given by the governor of Virginia in 1790. Washington acquired these lands by purchase of two military warrants from Virginia soldiers who did not care to locate in the Virginia Military District. A federal law enacted in 1790 made Washington's titles insecure but he went to his grave believing that the lands were clear, for he listed them in his will at five dollars an acre. In 1806, Joseph Kerr, knowing that the titles to the Washington lands had not been perfected made three entries covering these tracts, and the present owners hold their titles from him. Numerous attempts have been made to get Congress to reimburse the Washington estate for the loss of these lands but all efforts have failed.

Sequent Occupancy of a Village on the Ohio Till Plain:—By Alfred J. Wright, Ohio State University, Columbus, Ohio.

Typical of the many villages which characterize the densely-populated till plain in southwestern Ohio is Waynesville on the Little Miami River. During its steady growth, over a period of a century and a quarter, the utilization of the environment assumed a series of cultural patterns the examination of which is the thesis of this paper, to the end

that the qualities of relationship may be determined in so far as they pertain to the natural environment and its configuration in the immediate site.

The culmination of this series of regional economies is integration with the economic life of large centers whose major activities are attuned to the remote as well as the immediate environment.

Nationalistic Elements in Farming in Northwest Ohio.—By CARL DUDLEY VARVEL, Ohio State University, Columbus, Ohio.

The farming population in the Lake Plains of Ohio is evenly distributed so far as nationality antecedents are concerned. However, there are certain localities where the majority of the people are derived from a given stock and where, therefore, the nationalistic elements are discerned in the farming habits.

The Lake Plains on the whole are rich agricultural lands, devoted to general mixed farming with livestock and, in favored places, to specialized vegetable and fruit culture.

Among the people, those of Germanic origin are the most numerous. Yankees, other old Americans, French, Scotch, and Polish are represented in fair numbers. Those derived from other nationalisties are to be found in isolated instances. The first arrivals preempted the lands thought to be the best. However, it appears much of the best lands have passed into the hands of the people of Germanic origin. This, in the writer's opinion, is due to their superior methods of soil management, labor output and the tendency to build up the capital investment in the farms, over long periods of time. These superior methods among the Germanic groups are traceable, the writer believes, to the seemingly inherent love of the soil, evident willingness of self-sacrifice and the gratitude for economic opportunity offered for hard work to those who pioneered into these lands.

Some Elements of the Cultural Landscape on the Lake Plain of Northern Ohio:—By REUEL B. FROST, Oberlin College, Oberlin, Ohio.

The Lake Plain of Northern Ohio is generally considered that portion of the terrain between the present shores of Lake Erie and the outermost ridge, (Butternut) which marks the southern shoreline of an ancient glacial lake Maumee. There were formed on this Lake Plain at least two other continuous and well defined ridges which represent the margins of the lowering lake level at successive stands. Between the ridges or beaches the surface is monotonously flat, being broken by but few post glacial stream valleys, poorly drained, and consists of heavy clay to clay loam soils. In contrast, the ridges, although not prominent topographic features, are sufficiently high to give good drainage, and are composed of the lighter sandy, gravelly soils.

Cultural contrasts are just as striking. Instead of the roads following the surveyed lot lines, the early pioneer found the even-crested, well drained, more penetrable ridge tops the best sites for his roads. That influence has persisted down through the years until now the ridges are the modern East-west arteries of transportation and com-

munication; property lines have been adjusted to give ridge frontage; land utilization is different. There is a notable change in architectural design; and land values are greater along the ridges.

A Geographic Interpretation of Wheat Production on the Columbia Plateau:—By JOHN H. GARLAND, Ohio State University, Columbus, Ohio.

This paper is concerned with presenting a geographic study of the wheat producing area of the Columbia Plateau of Washington, Oregon, and Idaho in the following manner:

1. The importance of the Columbia Plateau in relation to other wheat producing areas of North America.
2. The location and size of the wheat producing area.
3. The importance of wheat production in relation to other activities within the area.
4. Relationships of wheat production to the complex of natural environmental factors of the area.
5. Important non-environmental factors.

Typography and its Utilization in the Fiord Portion of Central Norway:—By GEORGE D. HUBBARD, Oberlin College, Oberlin, Ohio.

Typography and its Utilization in the Fiord Portion of Central Norway.

This land of former profound glaciation is marvelously cut up by fiords whose origin has long been discussed. The truth among the theories is sought.

Preglacial stream erosion was at least a two cycle process as present forms testify. The relation of the ice remnants to this topography is shown. Man has been making much use of this part of Norway for many hundreds of years. His use of it is described and interpreted.

Influence of Physiography in the Campaign around Chancellorsville:—By KARL VER STEEG, College of Wooster, Wooster, Ohio.

The campaign around Fredericksburg and Chancellorsville is particularly interesting to the student of Geography, for the reason that it was influenced to a large degree by the topography of the region and was conducted by two of the most colorful characters of the Civil War, Stonewall Jackson and Robert E. Lee. Both were strategists of a high order who studied their territory with great care. Their movements were largely the results of earth control.

Richmond occupied a strategic position; the Blue Ridge Mountains to the west and the broad estuaries and deep valleys of a series of parallel rivers to the northwest, gave it natural defenses which played an important part in the campaigns in Virginia. The Confederate armies, having the advantage of operating on interior lines, utilized the parallel rivers as lines of defense. The Confederate generals, familiar with every foot of the region were able to put to use every natural obstacle in their campaigns.

At Chancellorsville the forest screen and rough topography were decidedly unfavorable to the Union forces who were, one might say,

penned up within the Wilderness, a region of dense forests, thickets and deep ravines. Lee and Jackson, taking advantage of Hooker's dilemma, divided their forces and out-manoeuvered him, forcing him to retreat.

A Phase of the Geography of Chattanooga, Tennessee:—By N. C. BURHANS.

The Downtown Mercantile Area. Constituting for the time being a culmination of a series of successive progressions from the site of Ross Landing to its present situation, the vital portion of the mercantile core represents a focus of master urban and inter-regional transport arteries. The natural basin of a small Tennessee tributary is the logical receptacle for the downtown retail district and to this matrix the urban structures have accommodated themselves. On the east and west, topographic obstacles in the form of hills hem in this basin, on the north the Tennessee itself, and on the south a cultural barrier, the railway terminal fabric. Sympathetic to the widening of the valley upstream, the cultural units have expanded from a narrow dimension at the river's edge to a wide base on Ninth Street. It is toward the south also that the vertex of the shopping area is located between Seventh and Eighth, Market and Broad Streets, where buildings rise to ten or fourteen stories. Analysis of the component elements of the downtown mercantile form reveals a vital nucleus of preferred shopping and banking territory with bulkier commodity dispensaries, light processing and public and semi-public institutions clinging with varying degrees of adhesion to this central location.

Human Embryos.

Dr. Dodds has prepared a very complete account of the development of the human embryo as it is known and understood today. The book confines itself to human embryology, and can not, therefore, be used where a comparative embryology is required. It is an exceedingly usable text, however, and is written with a clarity of expression and continuity of theme unusual in a subject as intricate as this. A very complete series of illustrations add immeasurably to the text material. Many of these illustrations are original. The last chapter, summarizing the general schedule of development, with its various possible anomalies, is exceptionally worth while.

Essentials of Human Embryology, by Gideon S. Dodds. vii + 316 pp., 182 fig. New York, John Wiley & Sons, Inc. $4.00.

Recent Advances in Botany.

This is the title of the latest addition to the "Recent Advances" Series of books on botanical subjects. This volume covers a selection of topics from several fields of botany, as the following chapter headings show: Some Theories Regarding Plant Structure, Palaeobotany, Experimental Methods in Relation to the Species Problem, Fungi-Reproduction, Fungi-Heterothallism, Fungi-Mycorrhiza, Algae-Phaeophyceae, Algae-Florideae, The Virus Diseases of Plants. The subjects chosen are timely, and their treatment is concise, yet comprehensive Each chapter concludes with a list of pertinent references. The book will prove valuable as a reference for the botanist who wishes to keep pace with the advance of his science on its many fronts.—B. S. MEYER.

Recent Advances in Botany, by E. C. Barton-Wright. 287 pp. Philadelphia, P. Blakiston's Son & Co., Inc., 1932. $4 00.

ON EUCRANGONYX MUCRONATUS FORBES.

A subterranean blind shrimp; in this paper reported for the first time from Ohio, with a discussion of the relation of the animal to the glacial period.

STEPHEN R. WILLIAMS,
Miami University.

Eucrangonyx is an amphipod genus with a number of species, all of which, as far as I know, are found in cool fresh water. *Eucrangonyx gracilis* has been dredged from Lake Superior. This genus is to be separated from the other genera of the amphipods by the possession of a secondary flagellum on the first antenna, a reduced endopod on the third pleopod, and a telson notched at the distal end.

Professor Forbes reported this crustacean in 1876 from wells and springs of McLean County and of Champaign County, Illinois. O. P. Hay found it in 1879 in an old well in Marion County, Indiana, and in 1931 it was pumped from a well on the Francis farm in Butler County, Ohio.

By inspection of the glacial maps these localities are all within and close to the boundary of the Wisconsin or last glaciation. According to the monographs by Leverett, the Bloomington and Champaign localities in Illinois and the Butler County locality are early Wisconsin, while Irvington, Indiana, is late Wisconsin glaciation.

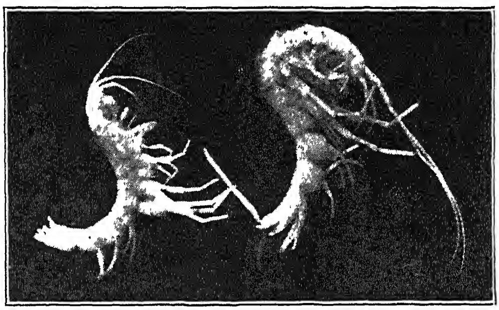
Wyandot Cave, Indiana, as reported by Banta, outside the glaciated area, has many *Eucrangonyx gracilis* but no *Eucrangonyx mucronatus*.

DESCRIPTION OF THE OHIO LOCALITY.

Ross Township is in the southern tier of townships of Butler County. The road from Ross (Venice) to Shandon starts in the wide first terrace or bottom of the pre-glacial Ohio Valley, now occupied by the Great Miami. It rises sharply to the second terrace or bottom and after some distance on this terrace it leaves it and curves upward around a high hill to descend into the valley of the Paddy's Run, a small tributary of the Miami. On the west slope of this hill and extending southward through the second bottom as far as the north line of Hamilton County lies the Francis farm. The never failing well at the west side of the house, dating from 1858, has furnished a number of specimens of the blind shrimp *Eucrangonyx mucronatus*, the subject of this paper, and many specimens of a Cyclops with eyes, *Cyclops bicuspidatus* Claus,

(kindly identified for me by Dr. Lela Ewers). On this slope of the hill the glacial deposit could never have been very thick. Most of the present day gullies show stratified limestone. There are several springs in the neighborhood, both above and below the level of this well which is 33 feet deep. A small stream from one of these springs runs westward parallel to the road about 250 feet north of the house. Its bed at this point as ascertained by Locke level is 25 feet below the well curb.

The surface of the ground at the barn well south of the house is ten feet below the house well curb. This barn well was formerly about 20 feet deep and would go dry in the summers. Some years ago it was deepened. After passing through a heavy layer of limestone just beneath the old bottom they found an abundant supply of water and the well is now permanent.



Eucrangonyx mucronatus Forbes. Female on left; male on right.

The house stands on an outlier from the higher hill to the northeast and I am assuming that there has been in the country limestone, both before and since the glacial withdrawal, a connecting series of solution channels spreading under the ground like a spider's web at a level of about thirty feet below the curb of the house well. The entrance to this network may have been through the spring to the northeast or through the bed of the stream flowing from it and by some such pathway the Eucrangonyx may have followed the ice cooled waters into the passages and by these the eyed Cyclops may return again to open water whenever it finds the way. Eucrangonyx, being already adapted to darkness, would only need to escape if driven by a scarcity of food. Forbes' paper states that in very wet weather the Eucrangonyx makes its appearance at the mouths of the drains.

As long as the forest covered the hills the surface erosion would be slight and the subterranean solution channels would very gradually increase in size and area, thereby increasing the range for these animals. When the forest was cut away the level of the ground water was lowered abruptly and the available area of these solution channels was probably reduced. This would kill off the animals in all unfavorable situations and permit them to persist only where a concentration of water, as in a well like this one, would tide them over the drier parts of the year.

As a matter of fact the drier time of the year is when more shrimps are taken from the well. It formerly was an open well operated by a windlass and buckets and shrimps were rarely seen, if ever. Now that there is a pump and the top is covered over perhaps the creatures swim up into the tube as a hiding place. More than a dozen specimens were taken during last September and October, while only one has been collected since. This may indicate that when the ground water is higher and the area available for occupation is greater the animals do not stay in the well. Since the summer temperature of the well water is 60° F. and the winter 58° F. the temperature would not be a deciding factor.

CHARACTERS CORRELATED WITH CAVE LIFE.

The specific character in this Eucrangonyx is the extension of the telson of the adult male into an elongate clublike structure. This gives the specific name *mucronatus*. The antennae and legs are longer in proportion than the same structures in Gammarus.

Ross, in the Proceedings of the Iowa Academy of Science, states that the young Eucrangonyx has a few slightly pigmented hypodermal cells representing a rudimentary eye, but he reports that according to Packard the adult brain has the optic lobes still but no optic nerve or eye.

THEORETICAL CONSIDERATIONS.

Graeter "Die Copepoden der Unterirdischen Gewaesser" states that there are two types of cave dwelling animals.

1. The changeable type which have wandered into caves in recent times and have adapted themselves to the environment.

2. The conservative type. These, in spite of long cave dwelling, remain unchanged keeping their superfluous eyes.

Banta reports *Cyclops bicuspidatus* with normal eyes from the darkness of Mayfield's Cave. It is the most abundant Cyclops in the plankton of Echo River, water temperature 55° F., Mammoth Cave. Kofoid considered this an adventitious and temporary member of the cave fauna since it can escape in any high water period. This same Cyclops appears in the Illinois River and in the Great Lakes in the cooler part of the year. Strangely enough the specimens from Echo River have antennae and furcae shorter than do the species from the Great Lakes.

To these two types I would add a third. Also a conservative type which was already blind as a surface form.

These entering cave conditions would survive because already adapted.

As examples I would cite:

1. The blind isopod, *Cecidotea stygia*, which is found in caveless regions as well as in caves.

2. The European cave shrimp *Niphargus*, both pale and blind, which is not uncommonly found in cold surface waters.

3. Dr. Menzel reports blind *Canthocamptus typhlops* in mossy bogs as well as in caves. The swamps furnished conditions under the vegetation much like those in caves.

Many cave dwellers are originally microcavernicolous forms. After a certain proportional dimension is reached, any size of cleft or cavern would be infinite in size for a small enough animal.

The possible plant food in solution channels would be bacteria, fungi and rootlets of higher plants, but of course no green plants. As a result the larger animals would need to be carnivorous. One Niphargus is reported to have eaten meat equal to his body weight in twenty-four hours.

At the first glance shrimps would appear to belong to Graeter's first class above because of the many forms adapted to subterranean waters. A large proportion are blind, some having lost the optic lobes, others with optic lobes having lost the cornea and pigmented cells, the visual elements, and others still which have functional eyes but reduced in size.

To quote Miss Weckel (Ward and Whipple, Freshwater Biology, p. 838), "Of the twenty species (of amphipods) known, ten or eleven seem to be inhabitants of caves, wells or springs. Not all have their eyes reduced, but the species of the genera *Crangonyx*, *Stygonectes*, and *Apocrangonyx* are actually blind and there is a blind species in each of the genera *Eucrangonyx* and *Gammarus* while the other species of these two genera show all transitional stages from well developed eyes to eyes more or less reduced. The correlation between subterranean life and reduction of the eyes is very evident in this family." Or as I should prefer it stated—The correlation between reduction of the eyes and subterranean life is very evident in this family. Are they eyeless because subterranean or subterranean because eyeless? It seems to me that in this specific case they are subterranean because they are eyeless.

It can hardly be possible that near the close of the Wisconsin glaciation twenty-five to fifty thousand years ago an eyed

shrimp could have entered the ground at Bloomington and Champaign, Illinois, Irvington, Indiana, and Shandon, Ohio, and in these separate places have modified in exactly the same way to become blind and mucronate. It is, however, very reasonable to suppose that a blind and mucronate shrimp, living in the deeper portions of the flood waters below the glaciers could be left in favorable situations along the morainic edges where the glacier remained long enough to allow it to establish itself and persist to the present time.

Favorable situations for the preservation of these creatures would not be common, either at the edges of the ice fields or back of the moraines in the thinner till, so the main body of these animals would have gone north with the cold water and the ice. If these shrimps are still in existence in their primitive cold surface water habitat anywhere it should be far north in Canada where the water is now as cool as it was at the former glacier's edge in Illinois, Indiana, and Ohio.

BIBLIOGRAPHY.

1907. **Banta, A. M.** Fauna of Mayfield's Cave, pp. 1–108. Bibliog. Carnegie Institute.

1918. **Brehm-Eger.** Ein Sammelreferat, Naturw. Wochenschrift, Bd. XVI, Nr. 4. S. 49–53.

1916. **Fenneman, N. M.** Bull. 19. Geological Survey of Ohio.

1876. **Forbes, S. A.** Bull. No. 1, Ill. Nat. Hist. Survey, pp. 3–25.

1910. **Graeter, E.** Die Copepoden der Unterirdischen Gewaesser Inaugural dissertation.

1882. **Hay, O. P.** American Naturalist, Vol. 16, p. 241.

1900. **Kofoid, C. A.** The Plankton of Echo River, Mammoth Cave. Trans. Am. Mic. Society, Vol. XXI, pp. 113–126.

1899. **Leverett, Frank.** Monograph 38. The Illinois Glacial Lobe U. S. Geol. Survey.

1902. **Leverett, Frank.** Monograph 41. The Erie and Ohio Basins. U. S. Geol. Survey.

1888. **Packard, A. S.** Cave Fauna of North America. Mem. Nat. Acad. Sci. IV, p. 156; 28 plates, 21 figures.

1928. **Ross, L. S.** On Eucrangonyx mucronatus. Proc. Iowa Acad. Science, Vol. 33, pp. 325–336; 10 figs.

1918. **Weckel, A.** In Ward and Whipple, p. 838, Freshwater Amphipods.

Human Physiology.

An eminent Danish physiologist has revised his text for translation into English, the translation being made by Dr. Drinker of Harvard. The result is a rather stilted compendium of facts, with no attempt at arousing the student's interest or thought. The book might do for high school students, or even as a reference work in a college library, but for modern university students of physiology, who demand up-to-the-minute methods of presentation and critical discussions of the most recent facts, the book falls far short of the mark.

A Text-book of Human Physiology, by August Krogh and Katherine R. Drinker. v + 233 pp., 108 engravings. Philadelphia, Lea and Febiger, 1932. **$2.75.**

SEQUENT OCCUPANCY OF A VILLAGE ON THE OHIO TILL PLAIN.

A. J. WRIGHT,
Ohio State University.

The Ohio till plain is at its agricultural best in the Miami Valley in the southwestern part of the State. It is not only a pleasant countryside, but a vigorous and prosperous one as well. Typical of the many villages which characterize this densely-populated plain is Waynesville on the Little Miami River. Situated almost equidistant from the two largest cities of the lower Great Miami Valley, this village exemplifies the results of a period of industrial selection through which these towns and villages have passed as peripheral to the major urban agglomerations.

Its settlement dates from the most important event of the Miami Country, the treaty with the Indians at Greenville in 1795. During the century and a quarter of its existence, this village of 700 population has experienced a succession of regional economies which it is the purpose of this paper to examine, to the end that some of the qualities of geographic relationship may be determined.

The location of early Waynesville was on a canal or raceway dug on the west side of the river at a point where a meander could be closed by digging somewhat less than two miles. The configuration of the immediate site was at first determined by the extent of the well-drained river terrace or second bottom, the village constituting an attenuated agglomeration of pioneer dwellings grouped about the two grist and two saw mills which utilized the power of the raceway.

Immediately opposite there is a break in the border of glacial drift which gives the only easy access for several miles to the eastern upland stretching away toward the Scioto basin. The village, then, was situated at the crossing of a principal east-west highway and the main north-south road of the Little Miami Valley.

PIONEER STAGE IN THE SEQUENCE.

The economy of Waynesville during the first decades of the nineteenth century approached regional self-sufficiency. Over

all of this section of Ohio there was a magnificent stand of hardwood, the clearing of which was at once the initial step in the agricultural occupation of the area, and an industry as

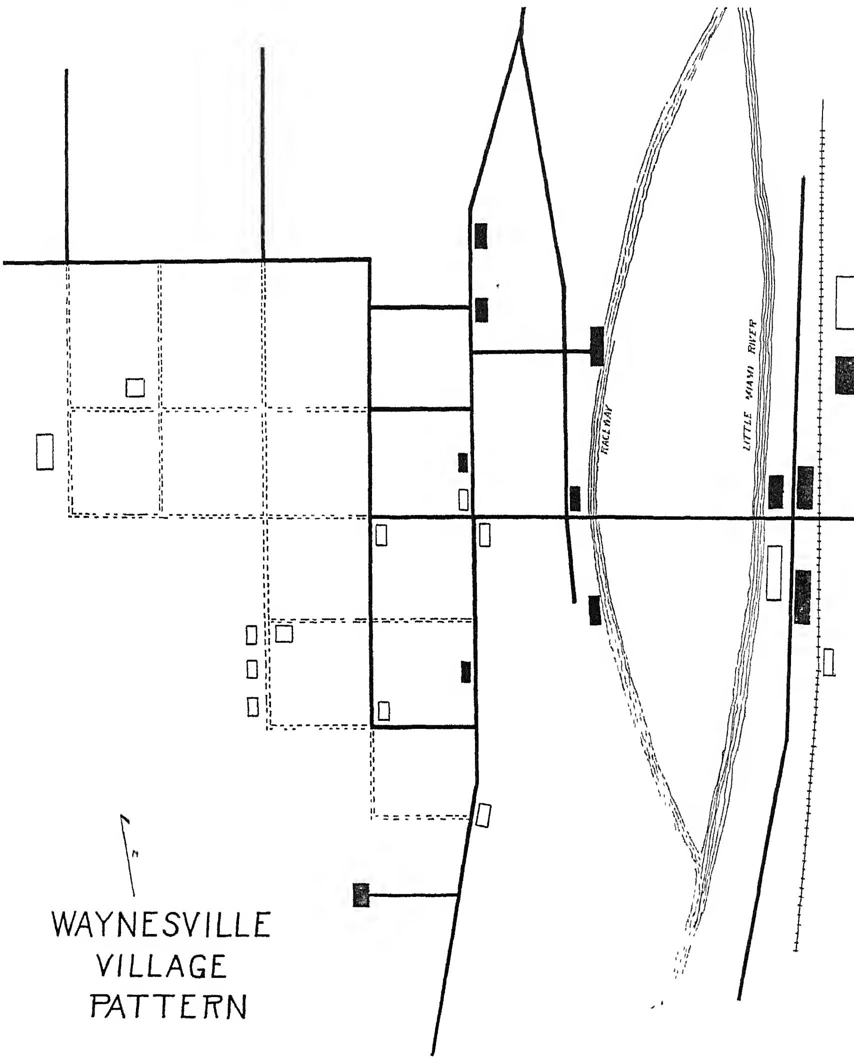


Fig. 1.

well. Corn and wheat were the principal crops; the great corn lands of the lower Miami Country gave rise to an important livestock industry before the upper portion of the Valley was settled. Steers and swine were driven to Baltimore

in increasing numbers until 1853, when Cincinnati began the packing of pork in an important way. The ubiquitous distillery accounted for a fair portion of the local corn crop; Waynesville had two large distilleries, and many of the adjacent farms distilled whiskey for local consumption. Wheat was milled by two establishments in the village; this region with others of the Miami Country produced most of Ohio's flour for several generations. In a word then, the essential characteristic of Waynesville during this pioneer period was the processing of ubiquitous raw materials for the satisfaction of the local market.

MIDDLE PERIOD.

The middle of the century witnessed the expansion of the village away from the river. (Fig. 1). Changing values assignable to environmental factors were faithfully reflected in the changed configuration of the village in its site, as well as the extent and variety of its manufacturing.

With the construction of highways and the use of steam power, the expansion of the village was onto the upland. Its main street became a part of the principal artery between Cleveland and Cincinnati; its major cross street was the southern-most highway between the Miami Valley and the Virginia Military Lands. The first railroad in Ohio, now the Pennsylvania Lines, followed the Little Miami River valley northward to Columbus and Lake Erie. Where this railroad crossed the east-west highway was formed the nucleus for Waynesville Station, embracing the depot, stock loading pens, grain elevator, saw mill and lumber yard, canning plant and the warehouses for wool and tobacco,—an agglomeration functioning integrally with the village but removed from it by the flood plain of the river. This period was characterized by the rapid growth of the village and the changed economic horizons resulting from the railroad and improved highway transportation. Manifestations of this period's growth are visible on every hand; new mills, new homes and the service of the principal utilities.

MATURING OF THE REGION.

The third stage of occupancy is characterized by the economic results of accessibility to other parts of the Miami Valley. This is reflected in the closing of the mills, cessation of local service by the railroad, and finally the crystallization of the economic

life of the Waynesville region into its present stage of commutation.

Whereas prior to the advent of the railroad, all of the Miami Valley was more or less tributary to Cincinnati and the Ohio River, steam transportation served to open up new economic horizons for these cities. Of greater interest to them than the southern market was the new market of the interior plains. They looked to the east, north and west made accessible by steel rails. The rapid growth of Dayton, Springfield, Hamilton and Middletown was ushered in by rail transportation. A new system of highways came into being, made necessary by the changed and vastly increased commerce within the Corn Belt. The greatest effect, naturally, would be noted not in the immediate marketing of farm products, but rather in the regional commerce adapting itself to the new and rapidly-growing manufacturing cities of the Great Miami Valley. When the automobile had demonstrated its superiority in handling certain types of traffic and the railroads had accordingly altered their service program, Waynesville found itself without the rail service to which it had become accustomed and upon which an element of its economy was dependent. Whereas 60% of the farm income of Warren County (Waynesville) is from livestock, divided almost equally between swine and cattle, the stock-loading pens are no longer used.* Although a constant part of the farm income is from tobacco, 19%, the warehouse is not used. Wheat still constitutes some 12% of farm income, but the two flour mills are closed and the elevator handles only a part of the local crop. Receipts from dairy cattle are greater, yet the milk car is no longer a daily feature of the morning train. Only one train each way stops at Waynesville, yet the number of trains passing through is as great as ever. The agent's time is now divided between two depots within commuting distance. Only the coal yard, corn canning plant, lumber yard which distributes but does not manufacture, and the elevator remain in operation at Waynesville Station.

In the village itself the creamery is closed; trucks swiftly gather up the separated cream for the larger creameries of Dayton and Cincinnati. The two flour mills have closed; farmers raise somewhat less wheat and truck their harvest to

*Data from individual Farm Schedules, Bureau of the Census, Department of Commerce, Washington.

one of the larger elevators in the Valley. The electric light and pumping station is now a unit in a great utilities concern which supplies two score of towns in the Valley. Two of the three slaughter houses are closed; dealers truck their supply from Dayton and Cincinnati. Wool and tobacco are bought up by buyers from distant warehouses. Of the four agricultural implement dealers, one remains with a stock scarcely reminiscent of former days.

COMMUTATION.

With these possibilities for employment closed, the number of wage-earners commuting to Dayton, Middletown and Hamilton has steadily increased. The twenty-mile drive contacts the villagers with several types of employment, outstanding among them being the General Motors and National Cash Register plants at Dayton; the Niles Tool Works at Hamilton; the American Rolling Mill plants at Middletown and Hamilton; the rag paper mills scattered from Hamilton to Dayton; and the tobacco factories of Middletown and Dayton. There is represented here a wide variety of wage job, with the manufacture of precision machinery predominating. An examination of commutation reveals a very definite type of wage earner engaging in it, a type of worker which the great tool plants and manufacturers of automatic and calculating machinery hold at a premium. There is then the coincidence of this demand being satisfied by the workers from a valley in which the small proportion of foreign-born are superior types from northwest Europe, and the native is readily absorbed in the precision ranks of skilled workers.

As have many other towns in the Valley, Waynesville has a diminishing proportion of retired farmers among its citizenry, yet its population is slowly but steadily increasing. Commutation plays an increasingly important part in the support of the Miami Valley. The Census of 1930 shows that during the decade immediately preceding these Valley counties grew more rapidly in population than the State as a whole: 17% as against 15%. Not all of the Valley counties gained however; five of the twelve declined in population. Warren county (Waynesville) gained more rapidly than any other county except Montgomery (Dayton). A more definite conception of the nature of this increase on the part of Warren county may be gained in noting the increase in the number of

families over a like period; in this particular Warren county gained more than any other county in the Valley.

Field study confirms the impression gained from these figures that through commutation Waynesville and other towns are crystallizing their economic life into a mature stage of economic regionalism in which abandoned local industrial features stand as mute evidence of former areal limitations imposed upon them. The sequent occupancy of this village is complete with the stage which witnesses its integration with the economic life of larger centers whose major activities are attuned to the remote as well as the immediate environment.

WHERE IS COLUMBUS?*

By E. F. Coddington,
Professor of Civil Engineering.

Those acquainted with Columbus will doubtless be interested in knowing that the exact geographical location of Broad and High has been determined from a station on top of the building at 8 East Broad Street as

Latitude—39° 57′ 44.984″ N.
Longitude—83° 00′ 1.605″ W.

It will be seen from these figures that the center of Columbus is less than 3 minutes from the 40th parallel of latitude and almost upon the 83rd meridian of longitude. In fact the 83rd meridian approximately parallels Summit Street, crossing High Street at the State House. The 40th parallel crosses Ohio State University campus in front of University Hall.

These calculations have as their center a station at Meades Ranch, Kansas, the location of which was determined by astronomical methods to be 39° 13′ 26.686″ latitude (almost the same as Columbus) but 98° 32′ 30.506″ longitude. From this point, triangulation lines have been extended in all directions, furnishing exact points from which other precise lines can be surveyed. Our Ohio line extends from Sandusky on Lake Erie to Portsmouth on the Ohio River, taking in Fremont, Columbus, and Chillicothe on the way.

This romance of lines is the work of the U. S. Coast and Geodetic Survey. Our country has become a network of lines, which, upon closer examination, are found not to be mere lines but a series of superimposed triangles, each angle the center of marvelous activity for measuring the extent of our continent.

In connection with this work, stations have been established which are available controlling precise local surveys. Two such triangulation stations are located in Columbus, one at the State Hospital on West Broad Street and the other on the old Ohio Brewery Building on South High Street. These two stations were established about 1927. When in 1928–29 the U. S. Coast and Geodetic Survey was working on the triangulation net for the entire eastern half of the country, it adjusted its system to include the Columbus stations.

Detailed information on these adjusted geographic locations is being published by the U. S. Coast and Geodetic Survey and can be obtained in the near future.

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*From Engineering Experiment Station News.

ORTHOGENETIC EVOLUTION OF DEGREE OF DIVERGENCE BETWEEN CARPEL AND FOLIAGE LEAF.

Studies in Determinate Evolution. VI*.

JOHN H. SCHAFFNER.

In the fourth paper of the present series on the nature of the evolutionary process, a brief presentation was given of the progressive divergence of character between the sporophyll and foliage leaf as one follows up the evolutionary sequence from the homosporous pteridophytes to the angiosperms.† A general series of sporophylls is now presented in order to illustrate the principle of progression and degree of divergence in detail. Only a carpellate series is given as the carpel is usually somewhat slower in attaining the extreme limits than the stamen. However, the stamen shows the same general sequence also, often in a very striking manner.

In the lower fern series, both eusporangiate and leptosporangiate, there is no difference whatever between the foliage leaf and the sporophyll except that the latter develops sporangia. In other words, the sporophyll is a foliage leaf and has all of its functions. These lower vascular plants are extremely simple systems as compared with the highest angiosperms. Figure 1 represents a leaf of Goldie's Shield-fern, *Dryopteris goldiana* (Hook.) Gr. The upper part of this specimen has sporangia while the lower part is sterile with the characters of the completely sterile foliage leaf. In this species, as in most of the lower ferns, some leaves are sterile, some are partly sterile and partly fertile, and some have the entire lamina covered with sori. There is, however, no dimorphism of any kind except that the reproductive areas have sori.

The first distinct step in the orthogenetic sequence is shown in a difference in size between foliage leaf and sporophyll.

*Papers from the Department of Botany, The Ohio State University, No. 306.

†Long-continued Determinate Orthogenetic Series. Ohio Jour. Sci. 31: 1–16. 1931.

This is well represented by *Asplenium pycnocarpon* Spreng., the Narrow-leaf Spleenwort (Fig. 2, a and b). The leaflets of the Sporophyll are usually smaller and considerably narrower than those of the sterile foliage leaves. There is thus the beginning of a degree of divergence between the two homologous organs. The leaves of the Net-veined Chain-fern,

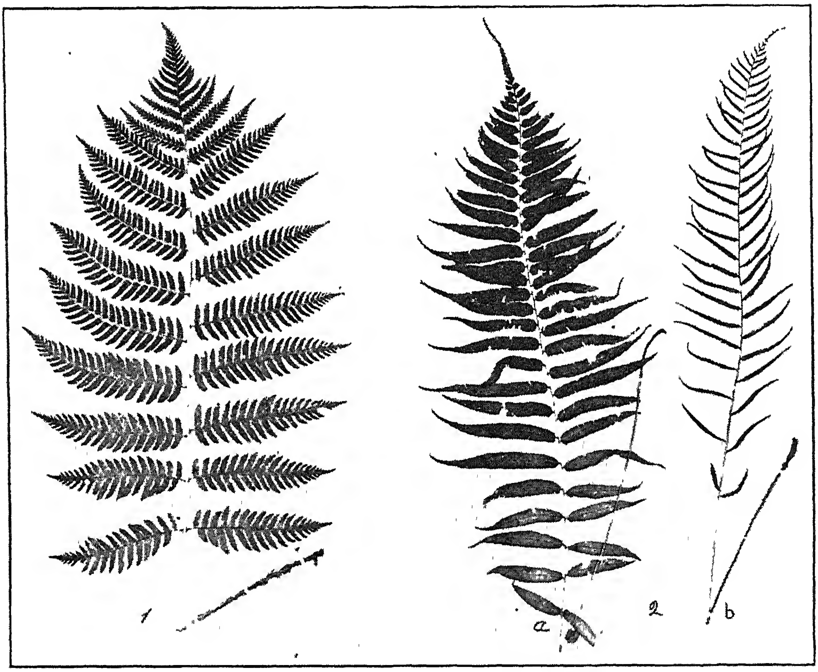

FIG. 1. *Dryopteris goldiana* (Hook.) Gr. A sporophyll with the lower pinnae sterile.
FIG. 2. a—Foliage leaf of *Asplenium pycnocarpon* Spreng.
b—Sporophyll of the same.
(All reduced to one-sixth natural size.)

Lorinseria areolata (L.) Presl. (Fig. 3, a and b) are more decidedly dimorphic, the pinnae of the sporophylls being greatly reduced in width. The extreme divergence in our native fern series is attained in the Sensitive-fern, *Onoclea sensibilis* L. (Fig. 4, a and b). The sporophyll is remarkably different from the foliage leaf. The foliage leaf is broadly triangular, deeply pinnatified, and with the segments usually undulate, sinnate dentate, or somewhat pinnatifid, while the sporophyll is without any expanded blade and is bipinnate. The pinnules

are contracted and inrolled over the sori into round, hard, bead-like bodies which become brown when mature. Several important hereditary potentialities have been added to the protoplast which come into action when the physiological gradient of the system, at the given point, is of such a nature as to throw the leaf into the reproductive activity. The

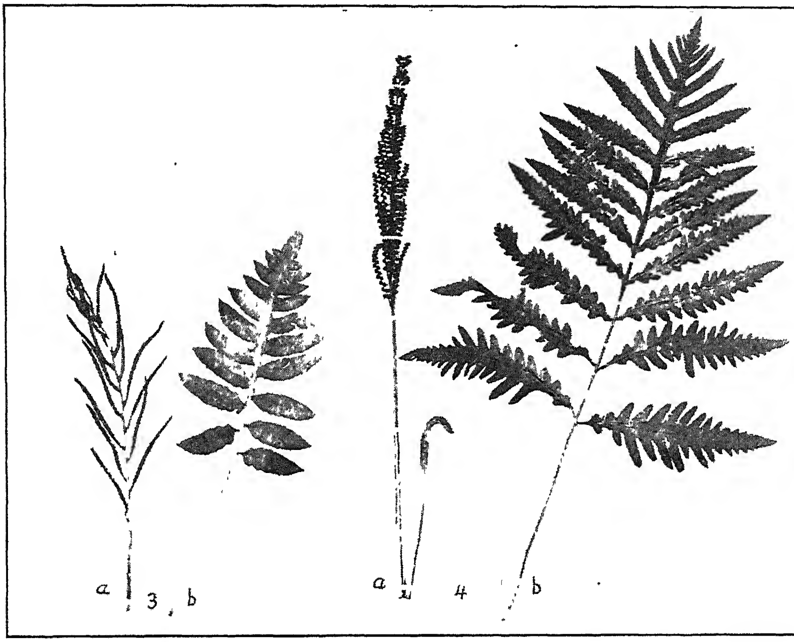

FIG. 3. a—Sporophyll of *Lorinseria areolata* (L.) Presl.
b—Foliage leaf of the same.
FIG. 4. a—Sporophyll of *Onoclea sensibilis* L.
b—Foliage leaf of the same.
(All reduced to one-sixth natural size.)

divergence of the sporophyll from the foliage leaf is shown most prominently by the compound condition of its pinnae, by the change in texture of the contracted leaf blade tissue, by the great reduction in the size of the pinnules, and by the inrolling of the pinnules over the sori. All these and other differences show a culmulative addition of potentialities in the protoplast. The same evolutionary sequence is shown in other families of living ferns.

There are only a few living heterosporous pteridophytes and none whatever that might form a transition link between the ferns and the lowest living seed plants, the cycads, the living heterosporous ferns all being extremely specialized and reduced plants. The orthogenetic sequence is, however, consistently continued in the lowest living Cycadales. In passing up to the cycads, a number of very fundamental potentialities have been added to the cell complex, which show their presence in the sporophylls. The time of sex determination has been shifted from the gametophyte to the sporophyte in the life cycle, and in all seed plants this determination always takes place at least as early as the beginning of the development of the sporophylls. The sporophylls, therefore, normally always show secondary sex dimorphism, while in the fern series there is no sex expression whatever, the entire sporophyte, including the leaves, being in the neutral state. The difference in sexual state, therefore, gives microsporophylls or stamens and megasporophylls or carpels. Because of the presence of the secondary female state in all the cells of the carpel, the carpel will produce megasporangia or ovules and in these megaspores. Since the megaspores are not shed, the female gametophytes are parasitic in the ovules. Thus many new hereditary potentialities are present to be expressed in the carpel as compared with the simpler system in the sporophyll of *Onoclea*, while nothing essentially new is added to be expressed in the foliage leaf except a few minor characters.

The lowest living cycad is *Cycas revoluta* Thunb. Figure 5 represents a carpel of this species. The carpellate leaf is greatly reduced in size when compared with the large pinnately compound foliage leaf. The blade of the carpel is still present showing prominent pinnules. The texture, surface, and color are decidedly different from the foliage leaf. The general differences are the same as in *Onoclea* but there is no tendency to enclose the sporangia in the leaf blade.

Figure 5 represents a carpel of *Cycas circinalis* L., which shows a considerable reduction in the leaf blade when compared with *Cycas revoluta.* An extreme type of *Cycas* carpel is represented by *Cycas normanbyana* F. Muell. (Fig. 7). In this species the ovules are reduced to two and the compounding of the vestigial blade is practically obliterated. There is therefore a decided difference between the carpel and the large, green, pinnate foliage leaf.

All the sporophylls considered so far are produced on indeterminate axes. The remaining members of the series are all flowering plants, the carpels being produced on definitely

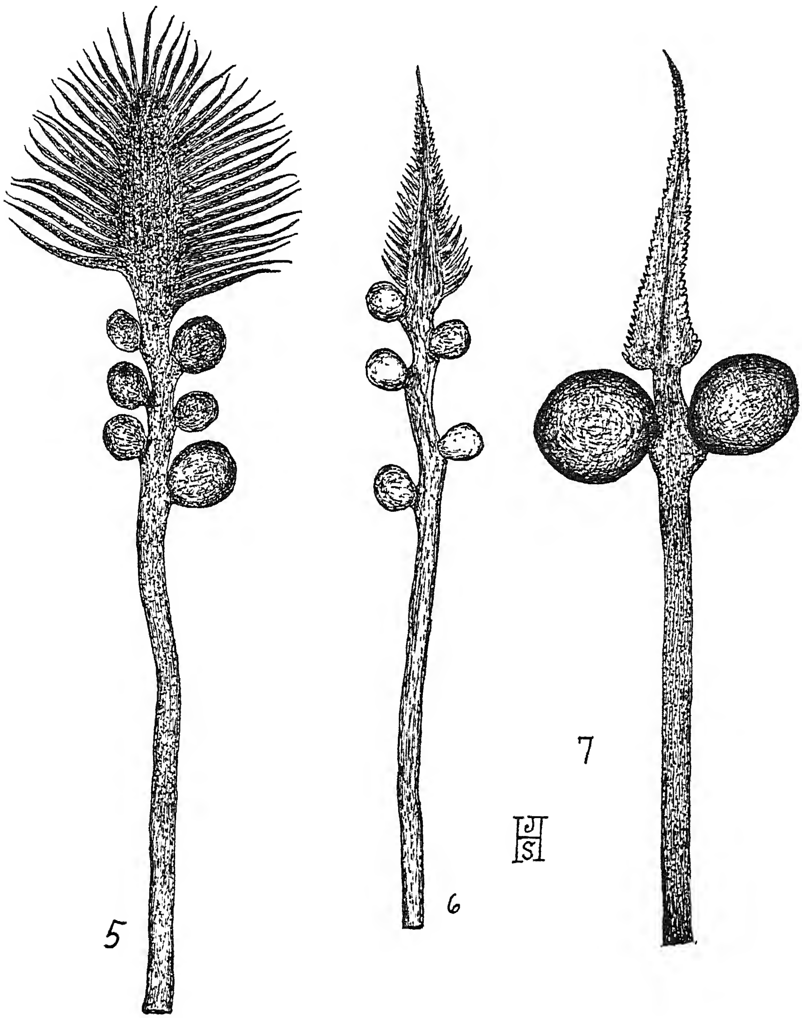

FIG. 5. Carpel of *Cycas revoluta* Thunb.
FIG. 6. Carpel of *Cycas circinalis* L.
FIG. 7. Carpel of *Cycas normanbyana* F. Muell.
(All reduced to one-half natural size.)

determinate reproductive axes. It will be seen that the reduction of the sporophyll in the evolutionary progression is not dependent on the introduction of a determinate reproductive

bud. The progressive reduction and specializiation of the sporophyll is an entirely independent evolutionary movement, although, of course, in all the higher forms the orthogenetic evolution of the carpel is necessarily associated with the orthogenetic evolution of determinateness of the floral axis.

Figure 8 represents a carpel of *Macrozamia fraseri* Miq. A decided reduction has taken place in the carpel as a whole when compared with the *Cycas* series. The petiole is very short although the petiole of the foliage leaf is comparable to those in *Cycas*. The ovules have changed their position and this new character is continued through the rest of the living cycad series. The last vestige of compounding has disappeared from the carpellate blade. In *Macrozamia denisoni* Moore and F. Muell. (Fig. 9) the carpellate blade is again much shorter than in the preceding species. The extreme is reached in species of *Zamia*. Figure 10 represents a carpel of *Zamia ulei* Dammer in which the blade is represented by a mere peltate cap and the entire structure is more contracted and compact. In *Ginkgo biloba* L. a much higher type of the Cycadophyta, where again there is no floral development, the blade of the carpel is reduced to a minute, transverse vestigial ridge, although the petiole is as prominent as the petiole of the foliage leaf.

The next higher group in the upward progression is the class of the Coniferae and the lowest plants in this series are the Araucariales, as indicated by their simple, rhythmical ontogenetic gradients, their primitive leaf arrangements, lack of peduncles, frequent proliferation of cones, and multicellular male gametophytes. In *Araucaria araucana* (Mol.) Koch. (*A. imbricata* Pav.), the carpel has a green leaf blade of considerable size (Fig. 11) while in *Araucaria rulei* F. Muell. the blade is decidedly reduced (Fig. 12). In *Cunninghamia sinensis* R. Br. (Fig. 13) the lowest living member of the Pinnales, although the carpel still shows a distinct midrib, it is much smaller and decidedly different in character from the foliage leaf. In the Pinaceae, the carpellate bract (blade) shows a progressive reduction in the various phyletic lines, although the problem is complicated by the evolution of a new structure, the ovuliferous scale, which makes the degree of divergence between the carpel and foliage leaf (needle leaf) unusually large. The extreme in specialization in the Pinales is reached in *Juniperus*. Figure 14 represents a carpel of *Juniperus*

virginiana L., the Red Juniper, magnified two diameters. These carpels are decidedly different in texture from the foliage leaves although nearly comparable in size. After pollination, the carpels of the minute cones all fuse together, become fleshy, and are of a dark blue color, so that the mature fruit finally simulates a juicy berry instead of a strobilus, which it is structurally. Thus the divergence between carpel and foliage leaf has been increased by the addition of important

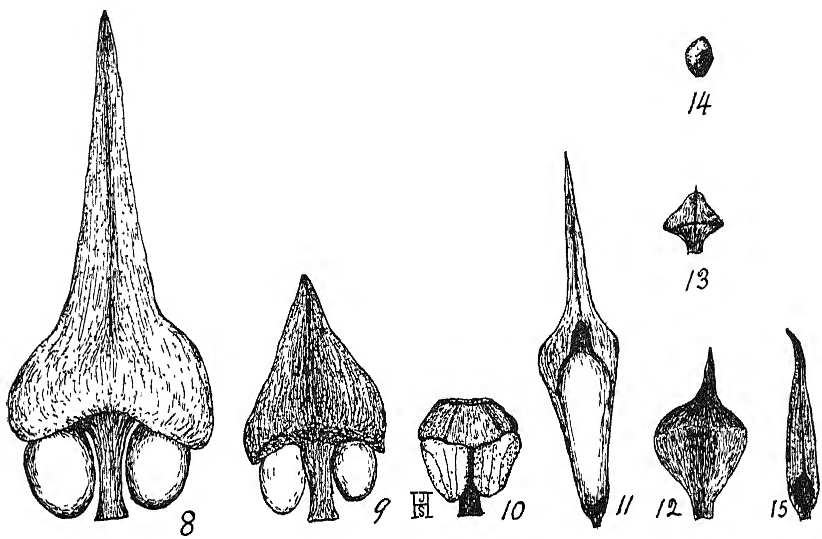

FIG. 8. Carpel of *Macrozamia fraseri* Miq.
Fig. 9. Carpel of *Macrozamia denisoni* Moore & F. Muell.
FIG. 10. Carpel of *Zamia ulei* Dammer.
FIG. 11. Carpel of *Araucaria araucana* (Mol.) Koch.
FIG. 12. Carpel of *Araucaria rulei* F. Muell.
FIG. 13. Carpel of *Cunninghamia sinensis* R. Br.
FIG. 14. Carpel of *Juniperus virginiana* L.
FIG. 15. Carpel of *Magnolia pterocarpa* Roxb.

(All reduced to one-half natural size except Fig. 14, which is magnified two diameters.)

characteristics to the former, which parallel more or less similar advances in the carpels of great numbers of angiosperm series. At the top of the next higher conifer series, the Taxales, the reduction of the carpellate strobilus and the carpel have reached the ultimate limit in *Taxus canadensis* Marsh. The whole structure is represented by a single ovule on a cushion of tissue from which a fleshy red aril develops after fertilization, and beneath this is an involucre of specialized leaf bracts.

The Angiospermae are an exceedingly complex group with many progressive phylogenetic series in both the Monocotylae and Dicotylae. In general the orthogenetic progression is essentially the same in all of them. The main series from the bottom to the top is represented by figures 15 to 23. The lowest type of known angiosperm carpel, as Hutchinson* has pointed out, is found in *Magnolia pterocarpa* Roxb., from the Himalaya region. Figure 15 represents a carpel of this species reduced to one-half the natural size to correspond with the preceding conifer series beginning with *Araucaria araucana* (Mol.) Koch. (Fig. 11). In order to represent the angiosperm series properly the carpels have been magnified two diameters. *Magnolia pterocarpa* is repeated in figure 16 so that a direct comparison can be made with the rest of the angiosperms. It will be noted that this carpel is very leaf-like, being flat and showing a sort of midrib and a comparatively inconspicuous stigma at the tip. *Liriodendron tulipifera* L. also has a thin flat carpel (Fig. 17). Passing upwards to flowers with a single cycle of carpels, a further advance has taken place as shown by the more typical apocarpous carpel of *Aquilegia canadensis* L. Figure 19 shows a somewhat more advanced type of carpel from the monocotyl series, in the loosely syncorpous condition of *Yucca filamentosa* L. A similar loosely syncarpous condition is also present in the dicotyledonous *Abutilon abutilon* (L.) Rusby, in which the leaf character of the carpel is still slightly in evidence (Fig. 20). Figure 21 represents a carpel from the specialized syncarpous gynecium of *Asclepias incarnata* L. The leaf character is becoming very obscure because of the complication of hereditary factors which are thrown into activity at this point in the ontogenetic differentiation. The degree of divergence from the character of the foliage leaf of the species is, therefore, very great. In the next step, the final general limit of the possible evolutionary progression is attained in the development of epigyny. Figure 22, a and b, represent long-style and short-style carpels of the dimorphic *Houstonia coerulea* L. Here the real carpel is represented merely by the top of the ovulary, the style, and the stigma. The lower part of the ovulary, represented below the dotted lines, is cauline tissue which was developed and differentiated

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*Hutchinson, J. The Phylogeny of Flowering Plants. Proc. International Cong. Plant Sci. Ithaca, N. Y. *1:* 413–421. 1929.

from the cortical rim around the center of the bud after the bud had stopped its growth in length.

The extreme limit of carpel specialization and divergence from the foliage leaf type is reached at the tips of the various

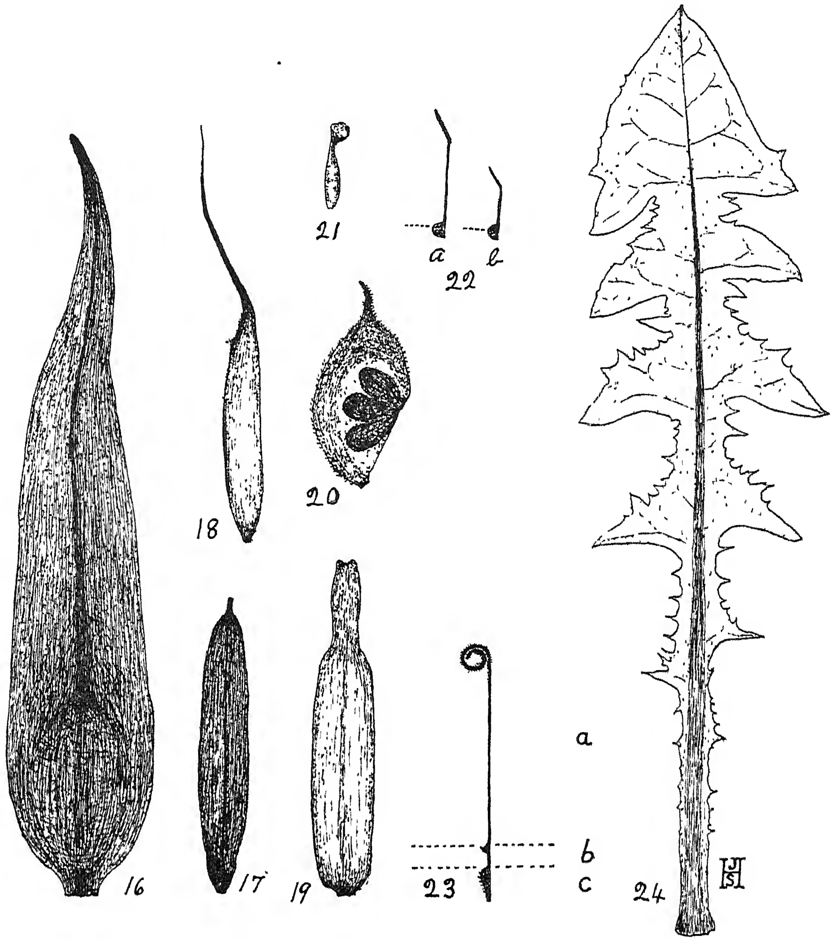


FIG. 16. Carpel of *Magnolia pterocarpa* Roxb.
FIG. 17. Carpel of *Liriodendron tulipifera* L.
FIG. 18. Carpel of *Aquilegia canadensis* L.
FIG. 19. Carpel of *Yucca filamentosa* L.
FIG. 20. Carpel of *Abutilon abutilon* (L.) Rusby.
FIG. 21. Carpel of *Asclepias incarnata* L.
FIG. 22. a and b—Long style and short style carpels respectively of *Houstonia coerula* L.
FIG. 23. Carpel of *Leontodon taraxacum* L.
FIG. 24. Leaf of *Leontodon taraxacum*.

(All magnified two diameters except Fig. 24, which is one-half natural size)

advanced phylogenetic lines of the higher angiosperms. Figure 23 represents a carpel of the Common Dandelion, *Leontodon taraxacum* L. This represents the very extreme culmination of the angiosperm evolutionary series. The real carpel is again represented morphologically only by the slender style and the coiled stigma (The portion *a*). All the ovulary except the cap over its unilocular cavity represents cortical tissue surrounding the center of the determinate flower bud, the ovulary factors and ovules not being expressed in the actual tissue representing the vestigial carpellate leaf. The ovulary itself shows an extreme specialization, being differentiated into two definite regions, the lower part of the cavity containing the single ovule and the upper part, just below the rim of tissue originally supporting the pappus and corolla tube, developing into a long slender neck. This neck is the structure which at the maturity of the seed elongates greatly to form the slender stem or thread connecting the fruit below with the pappus parachute above. Figure 24 represents an average leaf of the Dandelion reduced to one half natural size while the carpel in figure 23 is magnified to twice its natural size. A comparison of the two structures, which are homologous organs, will show the enormous divergence in form and function which has evolved. The measure of this degree of divergence is a measure of the position of the plant in the evolutionary scale. Almost as great a divergence of character is discovered if one compares the cross section of the stem bearing the leaf rosette with that of the pedicel below the individual florets. In this case also, the extreme of evolutionary complexity is again revealed when one compares the cross sections with each other of the rosette-bearing stem, the scape, the disk, the pedicel, and the lower part of the ovulary, which, as stated above, also represents cauline tissue. Such comparisons show the enormous complexities of the hereditary potentialities of the cell of the Dandelion when compared with that of a fern like *Dryopteris goldiana*, where the cell has the potentialities to produce but one kind of stem and one kind of leaf.

In the evolution of the carpel, then, there is an orthogenetic series progressing ever in one direction from the lowest to the highest types of vascular plants and the same progression is carried out in essentially the same way in all the multitudinous ramifications of the phylogenetic tree. The spectacle is truly marvelous and is not amenable to any anarchistic or witch-

doctor explanations of evolution, such as are still commonly given out at the present time. The evolution of the carpel is found to be strictly *kinetic*, *intrinsic*, *orthogenetic*, *progressive*, in a general sense *irreversible*, and *determinative*. It proceeds by the addition, step by step to the hereditary constitution of the cell, of fundamental potentialities which are neither initiated nor given direction by any apparent condition of the environment nor by any process of environmental selection. Those who still cling to teleological explanations like Lamarckian use and disuse, Darwinian natural selection, response to environment, or the newer deductions from experimental changes induced by x-rays or by other types of radiation, merely show their ignorance of the taxonomic system and the nature of the processes that were necessary to bring it into existence. The mutations brought about by chromosome aberrations or by the injury resulting from the effect of natural or experimentally produced radiation are not of the category one encounters in a study of the evolution of organisms. Neither the artificially induced mutations nor the abundant minute, natural mutations, which are purely superficial phenomena, give any evidence at present as to the nature of the processes which brought about the great fundamental, segregative, persistent changes, responsible for phyla, classes, orders, etc. nor for the remarkable orthogenetic movements, one of which is outlined in the present paper, which kept their steady course through great numbers of types of morphological systems and all sorts of environmental conditions. We must not confuse the problem of minute variation around a center and the problem of speciation with the real building up process of the fundamental potentialities which apparently never undergo change, never are entirely lost, never reversed when once fully established in the protoplast. Inhibitors or modifiers may be developed in the protoplast, or the environment may cause an ontogenetic change in the usual expression, but apparently not a real loss of any fundamental potentiality. The taxonomic system, which after all is what any theory of evolution is supposed to attempt to explain, is a direct contradiction of the belief that fundamental potentialities are subject to the same instability as one finds for the ordinary unit factors or genes with which Mendelian heredity is concerned.

Many of the present pronouncements on evolution would cause one to think that their authors had never indulged in a

study of the appearance and sequence of organisms in relation to geological time, had never made any study of the general taxonomic systems of plants or animals, but seemed to think that all one needed to concern himself about was an endless number of species and varieties which had no more fundamental relationships to each other than the pebbles on a beach and could be changed in one direction or another just as one can change the pebbles by use of hammer or file.

A Program for Teaching Science.

Anyone interested in the teaching of any of the sciences should read this yearbook which deals exclusively with a program for science teaching beginning on the elementary level and continuing through the secondary to the college level. It deals with many phases of the question from content and objectives to the training of science teachers in college. While one may disagree with some of the details given in the plan, it represents much thought and study on the subject and one must agree that it offers unity and continuity in the form of a definite program for science instruction instead of a few scattered and often unrelated courses in scientific subjects, a condition which is so much in evidence in our public schools today—D. F. MILLER.

The committee responsible for the thirty-first edition of the YEARBOOK (Part I) consisted of: Gerald S. Craig, Elliot R. Downing, Charles J. Pieper, Ralph K. Watkins, Francis D. Curtis and S. Ralph Powers (Chairman). The editor is G. M. Whipple.

The Thirty-first Yearbook of the National Society for the Study of Education; Part I; "A Program for Teaching Science," Public School Publishing Co., Bloomington, Ill., 1932. xii + 370 pp. Paper, $1.75; Cloth, $2.50.

Plants and Their Actions.

This pleasing little book was written according to the author so that the layman interested in fundamentals of science could "obtain some knowledge of Natural Science . . . . not primarily as a preparation for examinations." This is admirably accomplished. In simple non-technical language Professor Seward explains some of the major aspects of plants and how they act. Among other things he brings out in startling clearness the "Superiority of Green Plants to Animals" and our great debt to the plant group as a whole.

The entire book is extremely well written and although a glossary of 40 terms is included, there is little need for it, as each term as it appears is well explained.

A list of 17 texts and Floras are appended; these are, as would be expected, primarily British.—W. BERRY.

Plants: What They Are and What They Do, by A. C. Seward. 12 mo., 141 pp., 31 text-figures, Glossary and Index. New York, The Macmillan Co. $1.50.

Darwin's Bulldog.

This book makes a welcome addition to the existing biographies of Huxley. Like Huxley's own life, it is dynamic and vital, carrying the reader along on a continuous wave of action. Huxley liked to call himself Darwin's Bulldog, feeling that his mission was to defend evolution against all attacks. The author of the present volume goes farther, and credits Huxley with the creation of the evolutionary concept as it stands today—namely, the concept of man's natural place in the evolutionary sequence, and the implications arising from such a concept. The book provides fascinating and even exciting reading, and should be read by everyone interested in life and life processes—and who is not?

Huxley, by Clarence Ayers. 254 pp. New York, W. W. Norton & Co., 1932. $3.00.

PSEUDACRIS BRACHYPHONA (COPE), A VALID SPECIES.

CHARLES F. WALKER,
Ohio State Museum.

Since the summer of 1928, when Mr. Edward S. Thomas and I first collected specimens of a strange chorus frog in Hocking County, it has been apparent that there are two distinct forms of *Pseudacris* in Ohio. One, which is undoubtedly referable to *Pseudacris triseriata* (Wied), occurs widely over the state and in the western half is one of the dominant frogs. The second and less common species appears to be restricted, in Ohio, to hilly, wooded country, all of the records at present lying within the unglaciated, dissected plateau in the southern and eastern parts of the state. This form differs conspicuously from *P. triseriata* in the proportions of body and limbs, in dorsal pattern, and in color. An attempt to identify this frog has led to an investigation of the status of others in this poorly understood group, and while the validity of some of the named forms is doubtful, it seems certain that our southeastern Ohio *Pseudacris* represents a distinct form which is not currently recognized. It is surely identical with none of the species listed by Stejneger and Barbour in their check list (1923).

In "The Batrachia of North America," Cope (1889, p. 341), described as new a variety of *Chorophilus feriarum*, to which he gave the name *brachyphonus*. The description was based on a single specimen, probably no longer preserved, from "west Pennsylvania, near the Kiskiminitas River." A careful reading leaves no doubt that this description was based on the same frog that occurs in southeastern Ohio. Furthermore, a direct comparison with the types of *Pseudacris feriarum* in the National Museum, and with other eastern material shows clearly that our species is not the same as the one named by Baird. As indicated by Cope there is a general resemblance in proportions, but a marked difference in pattern. Furthermore, living specimens show a difference in color, and the digital discs of *feriarum* are slightly smaller. The Carnegie Museum collection includes a number of specimens from Pennsylvania and West

Virginia which agree closely with the Ohio material, showing beyond doubt that Cope's "variety" *brachyphonus* is actually a valid form with a considerable range.

(Photographs by Edward S. Thomas.)

FIG. 1. *Pseudacris triseriata* (Wied). The two specimens on the left are topotypes, from Mt. Vernon, Indiana. Specimen on the right from Warrick County, Indiana.
FIG. 2. *Pseudacris brachyphona* (Cope). Hocking County, Ohio.

Pseudacris brachyphona (Cope) may be briefly characterized as follows: A medium-sized *Pseudacris* with broad head, long

legs, no median dorsal stripe, ventral and concealed surfaces of the limbs yellowish in life. The width of the head is contained from 2.6 to 3 times in the body length. The length of the tibia is contained from 1.7 to 2 times in the body length. The toe discs are distinct, slightly larger than in *triseriata* or *feriarum;* the webbing of the toes is about as extensive as in those forms; the canthus rostralis is more marked. The vomerine teeth are in two small groups well separated in midline and opposite the posterior border of the nares. The dorsal markings consist of a

MEASUREMENTS OF A SERIES OF *Pseudacris brachyphona* (Cope).

Locality	Catalogue Number	Sex	Body length	Femur	Tibia	Foot	Head length	Head width
Westmoreland County, Penn.	Carnegie, 2028	♂	28	14	15	22	11	11
"	2029	♂	26	13.5	14	20	9.5	10
"	2030	♂	29	14	15	22	10	10.5
"	2031	♂	29	14	15	22	9.5	9.5
"	2032	♂	30	15	16	23.5	9.5	10
Pocahontas County, W. Va.	5339	♂	26	12	13	19	9.5	9.5
Scioto County, Ohio..	O. S. M. 183.1	♂	29	15	16	23.5	10.5	10.5
"	183.2	♂	28.5	14	15.5	23	10	10
"	183.3	♂	27	14	15	21	10.5	10
"	183.4	♂	29	14	15	21	10.5	10.5
"	183.5	♂	28	14.5	15.5	22	10.5	10
Hocking County, Ohio.	203.12	♀	31.5	15.5	16.5	24	10.5	11
"	239.25	♀	33	15	17	23	11	11
"	628.1	♀	31	14.5	15.5	21	10.5	10.5
"	628.2	♀	28	14	14.5	21	10	9.5
Pocahontas County, W. Va.	Carnegie, 5393	♀	33	15.5	17.5	25	10.5	11
"	5349	♀	34	15.5	17.5	25.5	11	11.5

conspicuous triangle between the orbits, and on each side, a broad, crescentic stripe extending posteriorly from the region of the tympanum, curving in towards the middle of the back. In about twenty percent of the specimens examined these stripes fuse in midline, giving rise to a cruciform pattern. Occasionally there is a spot above the vent. As in related species there are some irregularly spotted individuals which show no definite pattern. The limbs are spotted with dark. There are the usual cheek markings: a dark vitta extending back to the shoulder or side, below this vitta a narrow light line, and below this a dark line bordering the jaw. The inferior and

concealed surfaces of the limbs are decidedly yellowish in life. This color is most marked in breeding specimens and is present in both sexes. The vocal sac of the male is dusky anteriorly, this pigment partially obscuring the yellow of the throat. In some large specimens the throat is entirely black. The ground color of the dorsum varies through several shades of brown; in males olive-browns predominate, while the females are usually lighter in color and often exhibit warm reddish browns, reminiscent of those of *Rana sylvatica.* The females are larger than the males, this dimorphism being more apparent than in *triseriata.*

Those specimens which have the dorsal stripes fused in the center of the back show a pattern somewhat suggestive of *Hyla crucifer.* Apparently Cope's type had this pattern. A specimen from Marietta, Ohio (U. S. N. M. 3609) was actually identified as *Hyla pickeringii* (=*Hyla crucifer*) by Cope, and so listed in his work (Cope, 1889, p. 355). Wilcox (1891, p. 134) realizing that he had a peculiar form, described specimens from southern Ohio which were surely *Pseudacris brachyphona.* These too were identified as *Hyla pickeringii* by Cope. These misidentifications must be ascribed to carelessness since the resemblance between the two species is superficial.

It seems remarkable that this frog should have escaped the attention of herpetologists in the northeastern states for so long a period after it was described. A casual search of the literature has revealed only one reference to the name. A specimen of *Pseudacris* in the Field Museum, taken at Meredosia, Illinois, was said by Weed (1923, p. 49) to have a pattern similar to that described by Cope. I have examined this specimen (F. M. N. H. 3266) and have definitely ascertained that it is not *brachyphona.*

Pseudacris triseriata and *P. brachyphona* are known to occur together in Allegheny County, Pennsylvania and in several localities in southern Ohio. In Hocking County, Ohio, where most of my observations have been made, *triseriata* is found only in the larger valleys, filled with glacial outwash from the north. The breeding pools lie chiefly in cultivated land and no specimens have been found above the valleys. *Brachyphona,* in contrast, is essentially sylvan in habit, breeding in temporary pools along small streams and below springs. It ranges up the hillsides as far as such situations are to be found. In the summer months it is most frequently found in deep woods.

Its breeding season begins somewhat later than that of *triseriata* and is more prolonged. Clasping pairs and fresh eggs have been found as early as March 20th and as late as May 12th. In the same region our dates for *triseriata* eggs range from March 14th to April 16th. The eggs of *brachyphona* are much like those of *triseriata* and are laid in similar masses, attached to twigs, leaves, or grasses, often well below the surface of the water. In one small pond near the base of a wooded hill, both species have been found breeding, although not at the same time. The voices of the two are much alike but the call of *brachyphona* is given more quickly, with a higher pitch and a different quality so that the effect of a chorus is quite distinctive.

The known range of *Pseudacris brachyphona*, as indicated by the available material, extends from Beaver County, Pennsylvania (Carn. 2021, 4189) south to Lawrence County, Ohio (O. S. M. 358) and Pocahontas County, West Virginia (Carn. 5125, 5339, 5349), and from Adams County, Ohio (O. S. M. 476) east to Fayette County, Pennsylvania (Carn. 2740–42).* The actual range is doubtless more extensive, especially to the east where the relationship with *Pseudacris feriarum* of the Piedmont has not been studied. A total of one hundred and forty-one specimens has been examined from the area outlined above. Variations in the proportions of the body and limbs in this series are slight. The pattern is also relatively constant. Although there is every gradation from striped to spotted patterns, no specimens have been seen which indicate a transition to the three-striped condition seen in the other northern forms.

In summary, *Pseudacris brachyphona* (Cope) is a well marked species, known from eastern Ohio, West Virginia, western Pennsylvania, and western Maryland. *Brachyphona* differs from *triseriata* and *feriarum* in the absence of a median dorsal stripe, in the slightly larger digital discs, in the yellow color on the limbs, and in the character of the voice. From *triseriata* it also differs notably in proportions. *Triseriata* and *feriarum*, although differing in proportions, agree in lacking yellow on the limbs, and in having, except in spotted individuals, a median dorsal stripe. The voices of these two forms are very similar.

*Dr. E. R. Dunn, who has independently reached similar conclusions as to the distinctness of *Pseudacris brachyphona*, writes that the Academy of Natural Sciences has six specimens (18767–8, 18776–7, 17824–5) from Jennings, Garrett County, Maryland. This constitutes the easternmost record at present.

Their digital discs are developed to about the same extent. They seem much more closely related to one another than to *brachyphona* and the latter may have been derived from a different stock in the south.

I am indebted to Dr. Leonhard Stejneger and Miss Doris Cochran of the National Museum for assistance in the matter of nomenclature and for the privilege of studying the types of *Pseudacris feriarum*. Mr. M. G. Netting, of the Carnegie Museum, loaned important material from Pennsylvania and West Virginia, and other specimens were examined through the courtesy of Mrs. Helen T. Gaige, of the Museum of Zoology, University of Michigan, and Mr. Karl P. Schmidt, of the Field Museum of Natural History. For the accompanying photographs my best thanks are due Mr. Edward S. Thomas.

REFERENCES.

Cope, E. D. 1889. The Batrachia of North America, U. S. National Museum Bulletin 34.

Stejneger, Leonhard and **Thomas Barbour.** 1923. A Check List of North American Amphibians and Reptiles. Second Edition. Harvard University Press.

Weed, Alfred C. 1923. Notes on Reptiles and Batrachians of Central Illinois. Copeia, No. 116, March 15, 1923, pp. 45–50.

Wilcox, E. V. 1891. Notes on Ohio Batrachians. Otterbein Aegis, Vol. 1, No. 9, pp. 133–135.

Medical Entomology.

This book is a revision of the older work, "Handbook of Medical Entomology," by the same authors. The revision is rather far-reaching and the men have produced a book that has excellent possibilities both as a text and as a handbook. It is one which will also appeal to the more general reader in the field.

The illustrations, which are uniformly good, are very numerous and well distributed. The many diagrammatic drawings add much to the clearness of the text. A valuable feature is the numerous taxinomic keys with their accompanying drawings. There is a sufficient amount of material of a more strictly medical character to lend both interest and value to the work.

The bibliography is extensive and arranged by authors. It might have been more convenient if a topical classification had been used.—D. F. Miller.

Medical Entomology, by Wm. A. Riley and O. A. Johannsen. xi + 476 pp. New York, McGraw-Hill Book Co., 1932. $4.50.

Animal Biology.

Dr. Woodruff's "Foundations of Biology" has been so favorably received by biologists that the present work, which is a rearrangement of the older editions, should find a ready welcome. This volume, revised and renamed, is limited to animals. New material included consists of synoptic reviews of the principle phyla, and considerable work on human relations. The book is a very complete outline of modern biological viewpoints, including newer work on ecology, adaptation, and similar phenomena. For those interested primarily in the animal side of biology, it is a very workable text. Dr. Baitsell is publishing a laboratory manual to accompany this text.

Animal Biology, by L. L. Woodruff. xii + 513 pp., 296 fig., glossary. New York, The Macmillan Co., 1932. $3.50.

A REMARKABLE SPECIMEN OF CALLIXYLON NEWBERRYI (DAWSON) ELKINS ET WIELAND, FROM THE OHIO SHALE.*

WILLARD BERRY,
Ohio State University.

This spring while on a field trip with some students to examine the basal Ohio shale as exposed along the Olentangy River north of Worthington, Ohio, at the locality known as High Banks, we made a rather abundant collection of plant impressions. These impressions are all referable to *Callixylon Newberryi* (Dawson) Elkins et Wieland as interpreted by Arnold of Michigan.

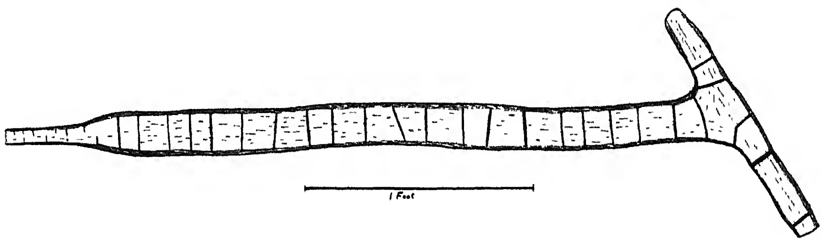
For the most part they are impressions of short pieces, well carbonized and in general not showing any vertical ribs, but with well defined cross marks or so-called nodal lines. These smaller pieces average 8 to 10 inches long and 1 to 3 inches wide. The remaining piece is larger and branched and is worthy of describing and figuring, as it differs in several ways from the previously described material referred to the species.

The impression herein to be described may be interpreted as a stem with a long branch from it. Such is probably the case, but if so it is difficult to account for the fact that while the branch has a width of about 5 cm. the main stem is only about 3.2 mm. wide. In this connection Professor E. W. Berry suggests that it may be due to the possibility that the stem was more solid wood and the branch more pith, hence upon compression the branch tended to spread out, whereas the more woody material was compressed without so much spreading. The dissimilarity of size could also be interpreted as a rhizome and an erect stem. This interpretation is also unsatisfactory because from the structural material *Callixylon* is related to *Cordiates* and should not have a rhizome. Also, the erect stem should come off more at a right angle than it does. No other interpretation presents itself unless we consider that the two pieces are not in organic union. That they are not in organic

*Read before Ohio Academy of Science, April 29, 1932, under the title "A Possible *Pseudobornia* from the Ohio Shale."

union does not seem to be the case, as the impressions show every sign of being one and the same piece. In this case I think we must accept the first interpretation, that it is a short stem with a long branch which, due to the mode of preservation, was spread wider than the main branch.

Another unusual factor is the angle of branch to stem. Arnold notes the angle of branching as about 45°. In this specimen the angle is at least 60° and there is no evidence of crushing below the branch or spreading above, such as should be found if the branch had been mechanically bent outward; neither does the rest of the branch bend in such a way as to support the supposition that it had been bent away from the stem.

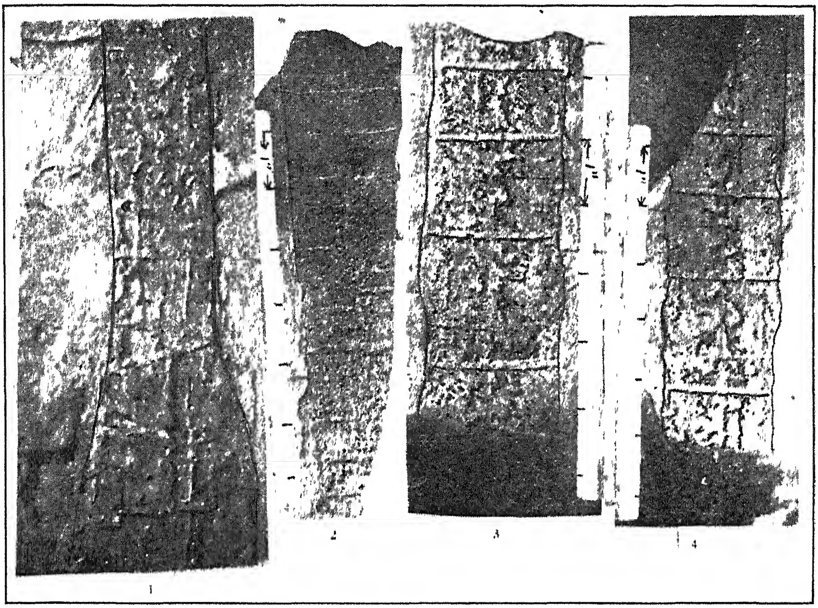


A third new factor is the decided sudden reduction in width of the branch near the outer end. The branch throughout most of its length averages 5 cm. broad and about 12 cm. from the outer end it decreases suddenly in breadth to about 2.3 cm. On both sides of this abrupt decrease the margins of the specimen are approximately parallel. The reduction in width occurs in about 5 cm. and below the reduction the nodal lines are heavier and farther apart and almost always complete. Above this point they are much less prominent and more indefinite.

Professor A. C. Seward, of Cambridge, who kindly examined part of this specimen, referred it to *Callixylon*, but stated that the so-called nodal lines were due to shrinkage cracks in preservation. Such they may be, but in this connection I raise the question: If they are shrinkage cracks should they not be filled with the matrix in which the fossil is imbedded? In this one specimen these pronounced lines are composed of denser coaly material than the rest of the stem.

Doctor Lewis H. Tiffany, of the Botany Department of Ohio State University, would refer it to the marine algae, and Mr. L. C. Li, a student of algae, would refer it to the red algae.

In this connection it may be noted that the modern red algae, although very much smaller than the specimen in question, exhibit very similar tendencies, i. e., branches may be broader than the stem and may taper abruptly near the terminals, and they also tend to produce nodal elements. It is faintly possible that this fossil represents a new fossil algae and not *Callixylon*. Petrified material exhibiting the definite nodal elements is needed to prove it new, however.



It is of interest to note in connection with these specimens that they were collected within 3 feet of the bottom of the Ohio shale where its (Ohio shale) contact with the Olentangy shale could clearly be seen.

The specimen may be described as follows:

Callixylon Newberryi (Dawson) Elkins et Wieland.

1859. *Calamites inornatus* Dawson. Jour. Geol. Soc. London, Vol. XVIII, 1861–62, p. 310, pl. XVII, fig. 56.

1931. *Callixylon Newberryi* Arnold. Contributions Mus. Paleon. Univ. Michigan, Vol. III, No. 12, pp. 207–232.

Impression of stem and branch. Branch about 1 mm. long and averaging 5 cm. in width except at outer end where it abruptly tapers to a width of about 2.3 cm. Stem smaller

than branch, about 34 cm. long and averaging 3.2 cm. wide. Angle of branch to stem about 60°. There are 5 very definite "nodal lines" on the stem and 21 on the branch, exclusive of the narrower part which has several rather indefinite ones. Indications of vertical ribbing very slight, although other specimens show it. On the stem the "internodes" vary in length from 3 cm. to 10 cm. On the branch they are about 4 cm. long.

Occurrence: Basal Ohio shale, High Banks, Franklin County, Ohio.

Figured specimens in collection at the Geological Museum, Ohio State University, Columbus, Ohio. Reversal in collection at Johns Hopkins University, Baltimore, Maryland.

The Insect Menace.

As Doctor Howard has stated, this book is written in order to arouse the general public to an appreciation of the real menace of the insect to humanity. This he has attempted to accomplish by presenting some very important and especially interesting material from various phases of insect life and by citing some outstanding economic problems. The early view point of the public toward the man who was interested in insect life merely as a collector is shown by the treatment and consideration he received from people in all walks of life. Only in recent years has an entomologist been looked upon as a benefactor to society. The great development in the work upon economic insects has been accomplished within the past fifty-five years. Insects have existed about forty million years, while man has been present about four hundred thousand years. Man may prove to be an unsuccessful experiment in nature, but the insect has persisted and has demonstrated that it is a success as a biologic form. Therefore, the fight between man and the insect is very much in favor of the latter because of its successful establishment and diversity of forms. During this period of forty million years insects have become adapted and selected in many ways. They have developed in such a way as to be better concealed in nature and their ability to multiply enormously and a large number of species have been established. The estimate is now made at probably four million species. Also they have advantages such as chitinous exoskeleton and other structural adaptations. All types of foods have been used by different types of insects and the physiology has become greatly changed in different types. Many special adaptations have occurred too, such conditions as subterranean, aquatic and various types of habitats. Man has caused the artificial spread and unusual increase of insects in many regions of the world. Rapid transportation by automobile, the airplane and the dirigible have added new and more rapid means of spread, which have increased the effectiveness of the insect pest. Insects are discussed in their relationships to the carrying of disease organisms in the case of man, domestic animals and plants. The forms which are beneficial are also discussed as producers of commercial products, or as assisting man in the production of commercial products. But Doctor Howard has discussed those of beneficial status especially as they occur as parasites of injurious insects. Control of economic insects in its modern phases is also presented, especially from the fields of mechanical and chemical measures, the changing of farm practices and the use of quarantine methods. For the student or the average citizen who is not acquainted with these problems this should be a very interesting and enlightening account of the role of the insect in its relationship to the life and activities of man.—D. M. DeLong.

The Insect Menace, by L. O. Howard, Ph. D., LL. D. xv + 347 pp. New York, London, The Century Co., 1932. $3.50.

A STUDY OF FERTILITY IN THE BLOWFLY, PHORMIA REGINA MEIGEN.

FRANK A. COWAN,
Ohio State University.

In the rearing of blowfly cultures for use in the treatment of osteomyelitis, egg masses are occasionally obtained which fail to hatch. Sometimes this becomes widespread enough among the cultures to seriously interfere with consistent treatment of patients in the clinic. Consequently a study of the problem was undertaken* with one of the flies most frequently used in such treatment (*Phormia regina*) in order to determine:

(1) When sperm production begins in adult males,
(2) How long males produce active sperms,
(3) What part foods and underfeeding play in sperm production,
(4) How long the sperms remain viable in the females after copulation.

There is very little information available upon the subject of fertility in male insects, except by inference from hatchings made in connection with studies on egg production. Lowne (1890–1892) observed mature sperms in *Calliphora erythrocephala* within a few hours after emergence. Environmental factors, especially food, temperature and relative humidity (Wardel, 1930) have been shown to be influential in producing fertile eggs. Baumberger (1919) showed the necessity for yeast in the food of Drosophila and Guyenot (1913) found that sterile potato was not sufficient for complete development and reproduction in the same fly. Young and Plough (1920) have shown how temperature could produce sterility in drosophila.

Glaser (1923) states that houseflies need protein and sugar to produce eggs and that very few eggs are laid by females of *Musca domestica* or *Stomoxys calcitrans* unless they have mated. I have likewise observed this to be true for Phormia. The effects of larval feeding, adult feeding, temperature and humidity upon growth and maximum egg production in *Phormia regina* have been summarized by Miller, Doan and Wilson

*Work done as a part of the study upon the use of fly larvae in the treatment of osteomyelitis being made by the Department of Zoology and Entomology in co-operation with the Departments of Medical and Surgical Research and of Orthopedic Surgery, in the Ohio State University.

(1932) in studies upon this fly in connection with their treatment of osteomyelitis.

Larson and Fischer (1924) observed that one mating of the pea weevil (*Bruchus quadrimaculatus*) was sufficient to fertilize a large number of eggs.

Occurrence of Spermatazoa in *Phormia regina.*

Because of the importance of environmental factors, as shown by all writers, precaution was taken to grow all experimental cultures in cabinets under controlled temperature (28° C.) and relative humidity (60%). The standard foods (water, meat and sugar) were used and varied to meet the conditions of the experiments. Stock cages of flies were started which contained one hundred and fifty males and one hundred and fifty females in each cage.

Flies fed upon a complete diet.—The first experiment had to do with normally reared adults which were maintained upon a diet of sugar, meat and water. A number of males were removed daily for dissection and examined for the presence of spermatozoa. An equal number of females were removed at the same time in order to maintain the original sex ratio. The abdomens were removed from the males and placed in a drop of water on a microscope slide and dissected under a binocular. The last two abdominal segments were cut loose by drawing the point of a needle across the abdomen. This operation usually disclosed the testes in the cup-shaped hinder two segments. The male organs in Phormia closely resemble those of *Calliphora erythrocephala* as described by Lowne (1890–1892). The testes were next taken out, along with as much of the rest of the reproductive organs as possible, mounted in water under a cover-glass and examined with a compound microscope (10X occular, 4 mm. objective). Usually the weight of the cover glass was sufficient to force out the contents of the testes but when not, gentle pressure with a needle point was used. Although the spermatazoa were quite large and active and therefore not easily overlooked, material was sectioned and stained as a check upon this method.

No active sperms were seen in the flies examined during the first 48 hours, but during the third day sperms became abundant and were found so in most of those flies examined up to the twenty-seventh day. There was some variation in the amount of sperms in different individuals and a few flies were entirely infertile. Since these sterile males were found at various times during the experiment, it is probable that they had never developed germ cells. The results indicate that most of the males, however, remained fertile up to the time of their death. Dissection of a few dead flies substantiated this view by revealing, in several cases, sperms that were still capable of movement, though this does not necessarily mean that they were still capable of fertilizing eggs.

This experiment was repeated with another group of flies, extending over a period of 30 days, and almost identical results were obtained.

Flies fed upon water and sugar only.—In Phormia, as in other muscoid flies, few or no eggs are laid without some protein food in the adult stage. Obviously, sufficient food material is not stored by the larvae which develop into females for eggs to form in the adult. This contrasted with the same treatment in the males, gave an interesting comparison.

Experimental cages were started under the same conditions as in the first experiment except that in this case the only food provided was water and cane sugar. Ten males were dissected each day for the first week and five or more each day thereafter until the twenty-eighth day. Two males dissected late on the second day showed some sperms. From the third to the seventh day sperms were fully as abundant in these as they were in flies fed meat as well From the eighth to the twenty-eighth day there was considerable variation in the amount of sperms in different individuals, but completely infertile males were no more abundant than in flies fed upon a complete diet of sugar, meat and water.

Flies kept entirely without food.—Another experimental cage of flies was kept under the conditions stated above with the exception that no food was given them at any time after emergence. Most of these flies lived 4 days and some lived until the end of the sixth day. Examinations showed that sperms appeared on the third day as usual, and were quite numerous in all flies dissected up to the sixth day. Several individuals found dead upon the sixth day also contained living sperms. The results of this experiment show that, at least during the first few days of adult life, sperm production is independent of the feeding of the males.

The effects of underfeeding in the larval stage.—Underfeeding during the larval stage affects the adult female fly by increasing the preoviposition period, by shortening the length of adult life and, consequently, by decreasing the total number of eggs laid.

To determine the effect of underfeeding upon the males the following experiment was run. A large culture of larvae was started. Four groups of two hundred larvae each were removed from the culture at the end of 36 hours, 52 hours, 76 hours and 96 hours, respectively. Larvae which had fed but 36 hours failed to pupate and eventually died. All others pupated and emerged. Dissection of the males in these groups showed that sperms appeared at about the same time in each, regardless of the length of larval feeding. Some sperms were found at the end of the first day and were abundant by the third day. This indicates that the time and amount of larval feeding do not affect sperm production in male Phormias though they greatly affect oviposition in the females.

Viability of the sperms in the female.—It has been shown by careful counts that in the normal history of a new cage of adult flies many more males than females die during the first two weeks after emergence. It is quite possible, therefore, for a cage that originally held equal numbers of males and females, to contain few or no males after twenty-five to thirty days. In spite of this reduction in proportion of males, cages have produced fertile eggs for as long as sixty days, suggesting the

possibility that the sperms remain viable for some time in the female after copulation.

To test this the males were removed from two cages of flies. One cage was eight days old, the other eighteen. The first cage had laid fertile eggs once before the removal of the males and the second cage had laid fertile eggs six times. In both of these cages, subsequent to the removal of the males, fertile eggs were laid every second day over a period of eleven days. On the thirteenth and fifteenth days no eggs were laid and most of the females died soon after, being twenty-three and thirty-three days old, respectively, which is the average age of a cage. These results would indicate that sperms are viable in the female at least eleven days after copulation.

SUMMARY.

Referring back to the questions stated at the beginning of this article, we find that they are answered as follows:

(1) In the males of *Phormia regina*, sperms are present regularly on the third day and sometimes as early as the first day after emergence.

(2) Adult males continue to produce sperms throughout their life (at least 28 days).

(3) Although both larval and adult feeding affect fertility and oviposition in the female, fertility in the male is not affected by the length of larval feeding nor by the absence of protein from the diet of the adult. Males kept for six days without any food whatsoever, produced sperms normally until death from starvation.

(4) Sperms remain functional in the females for at least eleven days after separation from the males.

LITERATURE CITED.

Baumberger, J. P. 1917. The Food of *Drosophila melanogaster*. Proc. Nation. Acad. Sci. U. S. A., 3, 122–126.

Glaser, R. W. 1923. The Effect of Food on Longevity and Reproduction in Flies. Jr. Exp. Zool., 38, 283–411.

Guyenot, Emile. 1913. Etudes biologiques sur une mouche, *Drosophila ampelophila* Low. II Role des levures dans l'alimentation. Compt. rend. soc. biol., 74, 178–180. IV Nutrition des larves et fecondite, 74, 270–272. V Nutrition des aldutes et fecondite, 74, 332–334, VI Resorption des spermatozoides et avortment des oeufs. 74, 389–391.

Larson, A. O. and Fischer, C. K. 1924. Longevity and Fecundity of *Bruchus quadrimaculatus* as Influenced by Food. Journ. Agr. Res., 29, 297–305.

Lowne, B. Thompson. 1890–1892. The Anatomy, Physiology, Morphology and Development of the Blowfly (*Calliphora erythrocephala*), 2 vols. London, 1890–92.

Miller, D. F., Doan, Charles A., and Wilson, E. Harlan. 1932. The Treatment of Osteomyelitis (infection of bone) with Fly Larvae. Ohio Jr. Sci., 32, 1–9.

Wardel, Robert A. 1930. Significant Variables in the Blowfly Environment. Ann. App. Biol., Vol. XVII, No. 3, August, 1930.

Young, Wm. C. and Plough, H. H. 1926. On sterilization of *Drosophila* by High Temperature. Biol. Bull. Marine Biol. Lab. 51 (3), 189–198.

FURTHER STUDIES OF THE GENUS EMPOASCA. (HOMOPTERA CICADELLIDAE.)

PART I.

NINE NEW SPECIES OF EMPOASCA.

DWIGHT M. DeLONG,
Ohio State University.

During 1928 and 1929 the writer attempted to examine all available material and to bring together data and records on the species of minute green leafhoppers belonging to the Genus Empoasca. This work was published in January, 1931, as Technical Bulletin 231, U. S. Department of Agriculture, under the title "A Revision of the American Species of Empoasca Known to Occur North of Mexico."

Since the completion of that manuscript material has been collected especially in the western United States by the writer and a considerable amount of material has been forwarded for identification by other workers. The present paper includes the first new descriptions of North American species since the revision was published.

Empoasca obrudens n. sp.

(Figs. 1, 1a, 1b.)

Resembling *maligna* in general form and appearance, but with distinct genital characters in both sexes and with a distinct brown spot just before each inner apical cell. Length, 3.7 mm.

Vertex broadly rounded, slightly produced beyond anterior margins of the eyes, parallel margined, twice wider between eyes than length at middle. Pronotum twice as wide as long with humeral angles prominent, projecting, wider than the eyes.

Color: Pale green, vertex, pronotum and scutellum mottled with white and yellow. Elytra greenish subhyaline with a distinct brown spot just before each inner apical cell.

Female genitalia: Female last ventral segment more than twice as long as preceding. Lateral angles produced into elongate lobes. Central portion of posterior margin excavated almost two-thirds the distance to the base, obliquely incised either side of a rounded, rather narrow, sunken, median lobe.

Male genitalia: Male valve longer than preceding, segment broadly V-notched posteriorly. Plates long and narrow, almost parallel margined, tapered to pointed apices. Of the male genital pieces the lateral processes of the pygofers are long and rather broad to near the

apices, where they are narrowed to pointed tips and upturned. The chitinous spines of the tenth segment are broad and similar to *pergandei*, slightly curved forward and with an anterior ventral pointed tip.

Described from a series of ten female and six male specimens in the Ball collection from Flagstaff, Arizona, collected by E. D. Ball, August 7, 1929. Holotype female, allotype male, and male and female paratypes in Ball collection. Male and female paratypes in author's collection.

Some of these are marked locust and this is probably the food plant. This species is easily distinguished from all known species of the genus by the unique female segment.

Empoasca rubrafacia n. sp.

(Figs. 6, 6a.)

General form and size of obtusa, but distinctly marked by red bands on vertex and face and three brownish bands on pronotum and elytra. 3.5–3.75 mm.

Vertex broadly rounded, produced almost half its length before anterior margins of eyes, more than half as long at middle as width between eyes. Pronotum without prominent humeral angles, narrower than head.

Color: Pale green with a broad bright red band extending between eyes on margin of vertex. Face with a curved bright red band extending on either side from clypeus almost to margin of vertex where they are united by a curved band between eyes above antennae. Pronotum and scutellum almost entirely brown, anterior portion sometimes pale. A broad band extends across elytra just back of scutellum, but does not reach costa, and another across apex of wings including all the apical cells and extending farther anterior than apex of clavus, brown, veins in apical region pale. In faintly marked specimens the red bands on the vertex and face are usually conspicuous.

Female genitalia: Last ventral segment strongly roundingly produced from base.

Male genitalia: Male valve broad, roundingly produced. Plates rather long, upturned at apices, gradually narrowed to blunt tips and heavily set with coarse spines. Of the male genitalia the lateral processes are rather stout with divergent finger-like processes extending abruptly outwardly and slightly dorsally. The chitinous spines of the tenth segment are long, broad at base, rapidly tapered to a rather long narrow apical portion which is strongly curved ventrally and anteriorly.

Described from a series of twenty-four male and female specimens all from Arizona, collected by E. D. Ball during May, August and September, 1929 and 1931. Localities represented are Patagonia, Tucson and Superior. Those from Patagonia are labeled "B. willow."

Male holotype, female allotype and male and female paratypes in E. D. Ball collection. Male and female paratypes in collection of the author.

Empoasca bitubera n. sp.

(Figs. 9, 9a.)

A small green species with a bluntly pointed head, and with distinct genital characters. Length, 2.5–2.7 mm.

Vertex bluntly pointed, produced one-half its length before anterior margin of eyes. At least one-third longer on middle than next the eyes. One-fifth wider between eyes than length at middle. Pronotum with broadly rounded humeral angles. Elytra about one-third longer than abdomen.

Color: Vertex pale green or white with irregular yellow markings. Pronotum dull green, posterior portion sometimes darker. Elytra dull green to smoky, apex smoky, subhyaline, veins pale as in *alboneura*.

Female genitalia: Female last ventral segment long, posterior margin almost truncate, slightly produced at middle.

Male genitalia: Male valve broadly, angularly excavated posteriorly. Plates broad at base, not twice as long as broad, gradually narrowed to bluntly pointed apices. Of the male genital pieces the lateral processes of the pygofers are curved inwardly then curved abruptly outwardly with apices diverging. The apex is turned sharply upward. The oedagus is distinct by having a long narrow spine-like process which arises near the base, and another one which arises about half way from the base. The chitinous spines of the tenth segment are broad, slightly curved forward, apex abruptly pointed and curved slightly inwardly.

Described from a series of twenty-two male and female specimens collected at Tucson, Arizona, May 26, 1929. Yarnell Mts., Arizona, October 4, 5, and 8, 1929, and Cedar, Utah, August 28, 1930, by E. D. Ball. The food plant is marked "Guterh." Also a series of specimens collected at Santa Clara, Utah, May 5, 1929, and at Las Vegas, Nevada, May 6, 1929, from Gutierrezia.

Holotype male and allotype female and male and female paratypes in author's collection. Male and female paratypes in Ball collection.

Empoasca calcea n. sp.

(Figs. 8, 8a.)

Resembling *arida* and *abrupta* in general appearance, but with distinct genital characters. Length, 2.7–3 mm.

Vertex rounded, produced about one-third its length before anterior margins of eyes, about one-fifth wider between eyes than length at middle. Elytra one-third longer than abdomen.

Color: Vertex dull green washed with yellow. Pronotum smoky green with a row of five white spots sometimes fused, along anterior margin. Pronotum and elytra dull smoky green. Scutellum with a pale green band across middle. Veins of elytra paler.

Female genitalia: Last ventral segment of female with posterior margin slightly produced.

Male genitalia: Male valve almost truncate, slightly indented at middle. Plates one-half longer than combined basal width, rather rapidly, convexly narrowed on apical third to pointed apices. Of the male genital pieces the lateral processes of the pygofers are rather short and thick with apices enlarged and blunt, slightly upturned. Chitinous spine of the tenth segment long and thick, ventral half curved anteriorly and ventrally, apical portion rather abruptly narrowed and produced.

Described from a series of eighteen male and female specimens collected at Tucson, Arizona, during April, May and June, 1929 and 1930, by E. D. Ball. Part of these are labeled "Celtis."

Male holotype and female allotype in Ball collection. Male and female paratype in Ball collection and in the author's collection.

Empoasca reflexa n. sp.

(Figs. 7, 7a.)

In general appearance resembling *snowi* but slightly smaller and with different female genitalia. Length, 3–3.5 mm.

Vertex bluntly, angularly produced about one-half its length before the anterior margins of the eyes. One-half wider between eyes than length at middle. Pronotum with humeral angles strongly produced and prominent. Elytra long, produced about one-third their length beyond apex of abdomen.

Color: Vertex green, usually with a central white stripe and an oblique white dash next either eye. Pronotum variable, sometimes with three white spots on anterior portion. Elytra greenish subhyaline.

Female genitalia: Female last ventral segment with posterior margin slightly produced posteriorly.

Male genitalia: Male valve rather broadly rounded, plates triangular, tapered and upturned, sometimes flaring at tips. Of the male genital pieces the lateral processes of the pygofers are stout and have a recurved finger terminal process pointing inwardly in ventral view. In lateral view the tip is abruptly and sharply pointed. Chitinous spine of tenth segment long narrowed to a long sickle-like terminal half which is anteriorly and ventrally curved.

Described from a series of twelve male and female specimens collected at San Rita Mt., Arizona, July 17 and 22, 1930 and 1931, by Dr. E. D. Ball. These are labeled "Sapind."

Male holotype and female allotype in Ball collection. Male and female paratypes in Ball collection and in the author's collection.

Empoasca medora n. sp.

(Fig. 4.)

In general appearance and coloration resembling *aspersa*, but more robust and with distinct female genitalia. Length, .3 mm.

Vertex bluntly rounded, produced approximately one-half its length beyond anterior margins of the eyes, not quite twice as wide between eyes as median length.

Color: Vertex pale yellow, pronotum, scutellum and elytra pale green to white. Elytra rather uniformly mottled with smoky or gray. Veins white, margined with smoky.

Female genitalia: Last ventral segment longer than preceding, posterior margin roundingly notched either side of a broad median lobe, which is slightly indented at middle. These notches form a rather evenly rounded lobe at each lateral angle. Male unknown.

Described from five female specimens labeled Medora, N. D., collected July 25, 1924, by Dr. E. D. Ball.

Holotype, female and female paratypes in Ball collection. Female paratype in the author's collection.

Empoasca bidens n. sp.

(Figs. 2, 2a.)

A small blunt-headed species related to *alboneura*. Elytra mottled with smoky. This species can be distinguished easily from all others by the character of the chitinous spine on the tenth segment. Length, 2.8–3 mm.

Vertex bulbous, bluntly rounded, produced about one-third its length before anterior margins of eyes. Only slightly longer on middle than next the eyes. About one-third wider than long. Elytra produced almost half their length beyond apex of abdomen.

Color: Vertex white to faint greenish. Ocelli and a pair of spots above ocelli on vertex darker. Pronotum with anterior portion usually paler, marked with dark spots, usually a broad median pale stripe extending longitudinally across pronotum. Elytra smoky green, venation white, conspicuous.

Female genitalia: Last ventral segment with posterior margin roundingly produced.

Male genitalia: Male valve short, broadly rounded, plates rather strongly narrowed to produced attenuated tips (in ventral view) which are upturned. Of the male genital pieces the lateral processes of the pygofers are broad in ventral view and appear abruptly narrowed and upturned at apex. The chitinous spine of the tenth segment is broad directed ventrally and is terminated by two teeth with a concaved portion between.

Described from a series of four male and two female specimens collected at Hauchuca Mts., Arizona, by Dr. E. D. Ball, June 15, 1930.

Holotype male and allotype female in Ball collection. Paratype male and female specimens in Ball collection. Paratype male in author's collection.

Empoasca calcara n. sp.

(Figs. 3, 3a.)

In general appearance resembling *fabae*, but with distinct male genitalia. Length, 3.–3.2 mm.

Vertex bluntly rounded, produced about one-third its length before anterior margins of the eyes, more than one-third wider between eyes than length at middle. Pronotum with humeral angles prominently produced.

Color: Vertex pale green, marked with yellow. Pronotum dull green, anterior portion paler, with three rather distinct white spots just back of margin of vertex. Pronotum with a paler green spot near middle. Elytra smoky green, veins inconspicuous.

Female genitalia: Female last ventral segment rather roundingly produced.

Male genitalia: Male valve concavely rounded Plates gradually tapered to blunt tips. Of the male genital pieces the lateral processes of the pygofers are very short and setaceous. They are smaller than in any species described at present. The chitinous spine of the tenth segment is broad at base, curved posteriorly and strongly narrowed near the apex which is sharp-pointed.

Described from fourteen male and female specimens collected at Yarnell Heights, Granit Dell, Glenn Oaks and Patagonia, Arizona, during July and October, 1929 and 1930, by E. D. Ball.

Male holotype and female allotype in Ball collection. Male and female paratypes in collection of E. D. Ball and in author's collection.

Empoasca infusca n. sp.

(Figs. 5, 5a.)

Resembling *birdii* in appearance and color pattern, but with bright greenish tint and genital characters distinct. Length, 3.3–3.5 mm.

Vertex bluntly rounded, produced more than one-half its length before anterior margins of eyes, two-thirds as long on middle as width between eyes. Elytra long, more than one-third produced beyond apex of abdomen.

Color: Markings similar to *birdii*. Green washed with smoky brown. Vertex with a spot either side of apex, a spot next either eye

on base of vertex and a median stripe pale. Pronotum with three large spots on anterior margin and a median stripe on scutellum pale. Elytra with clavus and a transverse band before apex of clavus extending to costa of elytra brownish. Apices of elytra frequently smoky. In dark specimens the anterior half of elytra usually brownish with a pale area on middle of each costa.

Female genitalia: Last ventral segment with posterior margin gradually produced at middle.

Male genitalia: Male valve concave posteriorly. Plates rather long, convexly tapered to pointed apices. Of the male genital pieces the lateral processes of the pygofers are rather short, heavy at their bases and tapered to rather sharp apices. Chitinous spine of the tenth segment rather long, apical half slender and ventrally curved.

Described from a large series of specimens collected at Columbus, Canal Winchester, Carroll, and Worthington, Ohio, during April and May, 1931 and 1932, by Paul Oman, Dr. E. P. Breakey and the author, from Buckeye in shrubby growth.

Holotype male and allotype female in author's collection. Male and female paratypes in collections of the author, E. D. Ball, Paul Oman, and E. P. Breakey and the U. S. National Museum.

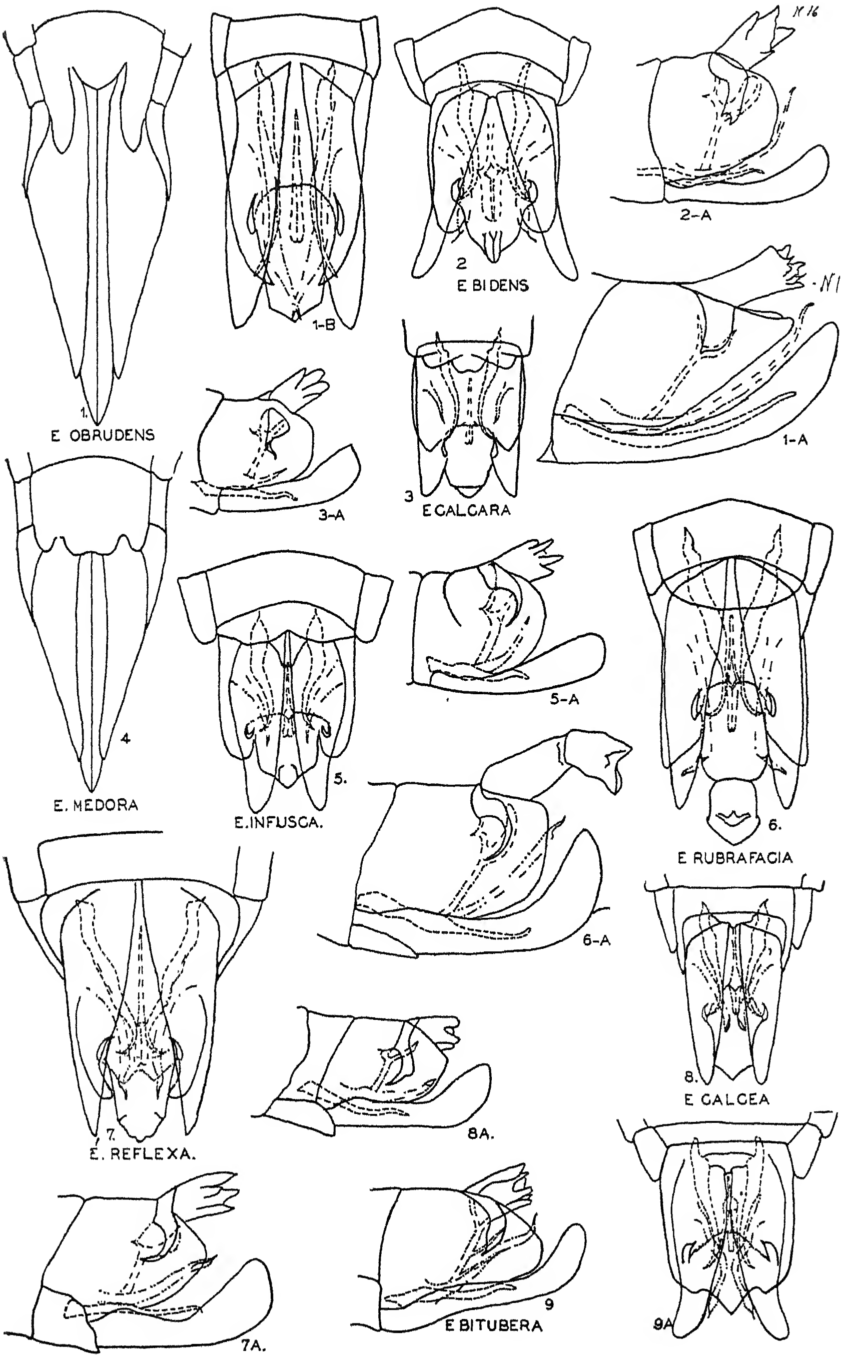
Superficially this species, *birdii* and *vincula*, cannot be distinguished because each is variable in intensity of color and the patterns are frequently very similar. The genital characters, however, are different and on this basis they are easily separated.

EXPLANATION OF PLATE I.

Genitalia of *Empoasca*.

- - - - - Indicate styles of male.
-·-·-·- Indicate oedagus of male.
-······· Indicate lateral processes of pygofers of male.

1. *E. obrudens*, female segment.
1a. *E. obrudens*, lateral view of male.
1b. *E. obrudens*, ventral view of male.
2. *E. bidens*, ventral view of male.
2a. *E. bidens*, lateral view of male.
3. *E. calcara*, ventral view of male.
3a. *E. calcara*, lateral view of male.
4. *E. medora*, female segment.
5. *E. infusca*, ventral view of male.
5a. *E. infusca*, lateral view of male.
6. *E. rubrafacia*, ventral view of male.
6a. *E. rubrafacia*, lateral view of male.
7. *E. reflexa*, ventral view of male.
7a. *E. reflexa*, lateral view of male.
8. *E. calcea*, ventral view of male.
8a. *E. calcea*, lateral view of male.
9. *E. bitubera*, lateral view of male.
9a. *E. bitubera*, ventral view of male.


1-B
2
E BIDENS
2-A
1.
E OBRUDENS
3-A
3
E CALCARA
1-A
4
E. MEDORA
5.
E.INFUSCA.
5-A
6.
E RUBRAFACIA
6-A
7.
E. REFLEXA.
8A.
8.
E CALCEA
7A.
9
E BITUBERA
9A

AN ADDITION TO THE KNOWN LIST OF OHIO MAMMALS.

B. P. BOLE, JR.,
Cleveland Museum of Natural History.

During the fall of 1929 the Cleveland Museum of Natural History had two men collecting small mammals in different parts of Ohio for about a month in all. In the course of operations about Adams County one of them, Mr. Philip Moulthrop, took a single specimen of *Reithrodontomys humulis merriami* (Allen), the Merriam Harvest Mouse. The specimen is an adult male and was taken at Rome, Adams County, on November 17, 1929.

The specimen is not distinguishable from specimens taken in Kentucky. The capture of the species in Ohio is not surprising, since the animal has been known for some time from Kentucky, just across the Ohio River.

Gregor Mendel, Pioneer in Heredity.

An exceedingly interesting biography of the founder of the science of genetics has been written by Iltis, and now appears as the first biography of Mendel in English, having been translated by Eden and Cedar Paul, who did such a fine piece of work in translating "Human Inheritance," by Baur, Fischer and Lenz. The present volume gives us an intimate glimpse into the life and work of the now famous experimenter. We learn much of interest and much of a surprising nature. Mendel, we are told, was a man of varied scientific interests, having made investigations not only in biology, but in meteorology and geology. In his biological researches, he hybridized mice, but was constrained to cease such activities, as being immoral in a priest. He conducted crossing experiments with bees. In the botanical world, where his chief interest lay, he used not only the peas which have made him famous, but columbines, snapdragons, slipperworts, sedge, pumpkins, hawkweed, vetch, four-o'clocks, beans, cinquefoil, mullein, violets, maize, and others.

Of especial interest is the fact that Mendel himself formulated the hypothesis of the interaction of factors resulting in epistasis. In his monograph on the hybridization of beans are contained not only the fundamental laws which are usually associated with his name, but also the elements out of which almost all of the later extensions and elaborations of the Mendelian doctrine have been made.

Mendel entered the priesthood for economic reasons and for leisure for experimental work. We learn that while at first he had leisure for his work, he was cramped for space. Later, when elected prelate, all the space he desired was at his disposal, but his duties robbed him of the time he needed. Still later, when both space and time were available, he records that he was handicapped by an excess of avoirdupois, having become too fat to make the long walks and hill-climbing so necessary in the collection of material. As many as twenty cigars a day were smoked in an effort to overcome the increasing weight.

The rediscovery of Mendel's work and the trend of scientific thought at the time are interestingly outlined in the later chapters.

The book is fine reading, and is authoritatively written. It should be in the library of every college and university, and on the personal shelf of every biologist.—L. H. S.

The Life of Mendel, by Hugo Iltis, Translated by Eden and Cedar Paul. 336 pp., 10 ill., 12 plates. New York, W. W. Norton & Co. $5.00.

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THE PROTECTION OF HAWKS AND OWLS IN OHIO.*

S. PRENTISS BALDWIN, S. CHARLES KENDEIGH,
AND ROSCOE W. FRANKS.

INTRODUCTION.

Among the changes in the world, brought about by the rapid development of methods and ease of communication during the last thirty years, may be seen the entire change of attitude of the farming population toward scientific agriculture. The farmer is no longer inaccessible, lagging behind and lacking in knowledge and news of the day, no longer farming by tradition and the turn of the moon as in the days which some of the eldest of us recall. The Federal and State Biological Surveys, State Colleges, and Experiment Stations have studied into every phase of scientific and practical agriculture, and the farmer, the progressive of today, has learned to accept and apply this information in daily life.

One of the last, but by no means least important, of the questions to receive careful study, and deserving immediate action, is this subject of the protection of our hawks and owls from wanton slaughter. All during our early days we recall how the cry of "hawk" on the farm meant always "chicken hawk" and all hawks were considered "chicken hawks" and, of course, we would run for the gun to destroy the invader.

It was the day of hear-say and tradition, and few of us ever thought to watch the hawk to see what he picked up when undisturbed, and discover that he came not always for the chickens, but frequently for the rats that were killing our chickens.

Of recent years the Federal and State bureaus have diligently gone after the facts in the case, by the examination of stomachs

*Contribution from The Baldwin Bird Research Laboratory (No. 24), and from Western Reserve University, Cleveland, Ohio.

of thousands of birds and by other forms of accurate observation, and the results of these studies we have attempted to gather in this paper.

We do this in the belief that the progressive farmer will no longer allow the destruction of these useful birds, and that intelligent sportsmen and game keepers will realize that these birds, as they come over the line, are not necessarily after the game, but come to free the estate of the greatest enemies of game—the rats, mice, and other rodents.

A most interesting example of change in attitude of a population over a great area occurred in Southern Georgia, where our laboratory operated an experiment station at Thomasville for ten years. Between and about Thomasville and Tallahassee are two hundred thousand acres, divided into large plantations, many of them ten thousand acres or more, owned chiefly for game shooting. Delightful in winter climate, a land which cannot compete with the intensive agriculture of other states, but rolling, open fields, with much waste land of some hard wood and some pine, largely fields of thickets and weeds, it is ideal for game shooting which is the chief business of the region.

In 1923 the sportsmen of this region formed a committee, which was called the Cooperative Quail Investigation, and by private subscription raised funds for a five-year study, which was operated by the U. S. Biological Survey with Herbert L. Stoddard in charge.

The sportsmen have published a most complete and able report of this work in "The Bob-White Quail," by Herbert L. Stoddard, offered by Charles Scribner Sons, New York, 1931.

Mr. Stoddard, already an able field naturalist, devoted five years to the study of quail with not only his scientific assistants working upon all phases of life of the bird, but with the hearty cooperation and active assistance of all the owners and game keepers in that great game territory.

That he is now recognized and retained by the sportsmen of the South and East as an able consultant expert justifies our quoting him as to the supposed harm of hawks and owls. Quoting as to certain hawks:

Sparrow Hawk:

"No instance of attack on bob-whites by the sparrow hawk (*Falco sparverius*) came to the attention of the Investigation. . . . In several instances individuals took up quarters temporarily on the fence

posts of propagating enclosures and made forays against the large grasshoppers on the ground beneath, without harming the quail chicks in the least."

Red-tailed Hawk:

"Unless red-tails are unusually numerous they may well be tolerated upon quail preserves because of their usefulness in catching cotton rats and other destructive rodents, and because they eat some snakes, which are the most difficult of quail enemies for man to control."

Red-shouldered Hawk:

"Time devoted to killing these useful birds on the quail preserves is worse than merely wasted, for no instances of quail destruction on their part came to light during the course of the investigation."

Broad-winged Hawk:

"This is one of the wholly beneficial species that should be given full protection at all times. Unfortunately it is so tame and unsuspicious that many are shot under the guise of protecting game or poultry."

Marsh Hawk:

"In view of the fact that not more than four quail were discovered in approximately 1,100 pellets, marsh hawks can hardly be accused of making serious inroads on the number of quail in a region. On the other hand, one or more cotton rats were found in 925 of these pellets. . . . Since cotton rats destroy the eggs of quail, the marsh hawk is probably the best benefactor the quail has in the area, for it is actively engaged in reducing the number of these rodents."

Cooper's Hawk and Sharp-shinned Hawk:

These two are indeed bad actors, both being bird killers and destructive to either birds or game, and Mr. Stoddard advises local control of them. But any attempt at control of these two species must be in the hands of really well informed persons, for, again quoting Stoddard:

"While the majority of hunters and outdoor people probably can tell the fully adult Cooper's and red-shouldered hawks apart, few can differentiate them in their juvenal plumages."

Fortunately in Ohio these two comprise less than eight percent of the hawks found in the State.

Passing now to the report of Stoddard as to owls:

"In view of the fact that the first two species (great horned owl and barred owl) are valuable in keeping skunks, opossums, and rodent enemies of the bob-white within bounds and that all are great enemies of the cotton rats . . . all owls should be regarded as beneficial on quail preserves."

"One of the most discouraging sights seen by us during the Quail Investigation was a beautiful barn owl, hanging by one foot from a steel trap on a quail preserve where cotton rats were abundant. The services of this bird would have been highly valuable to the owner, but its life had been sacrificed by the indiscriminate pole trap, which has no place on a well managed quail preserve."

That we have given so much space to these quotations from the quail fields of Georgia is because these are not the arguments of the so-called "sentimentalists," but the report forms the practical working basis of a great body of sportsmen throughout the southern and eastern states.

It is of interest in this connection to go back seventy-three years to quote John Kirkpatrick writing in the *Ohio Farmer* in 1859, on "The Rapacious Birds of Ohio," as follows:

"Nature is nicely balanced in all her relations and man's interference often does more harm than good. It becomes necessary to weigh judiciously the ultimate consequences of our actions or we may find evil effects when good only were expected."

RODENT PESTS AND CATS.

In many parts of the country it has occurred that the immediate result of the general destruction of hawks is a tremendous increase of rats and mice and other rodents, creatures which are vastly more destructive to birds of all kinds, whether game or song birds, than hawks can be.

With the increase of rodents in fields and homes encouragement is given to the increase of cats, until both song and game birds become victims of the cat pest added to the destruction already caused by the rodents. Both pests do far more damage than could possibly be caused by even the worst of hawks or owls. The Sacred Cat has already the advantage of the seemingly universal superstition that it is unlucky to kill a cat. Because of this superstition the people living in cities and towns, instead of destroying the multitude of surplus kittens, pack them into bags and baskets and drop them promiscuously over the country.

This superstition alone may well account for some of the scarcity of birds and game, instead of blaming it upon the hawks and owls.

ESTHETIC AND CULTURAL IMPORTANCE.

The hawks and owls are of considerable esthetic and recreational importance. An ever increasingly interested public is taking to enjoyments and pleasures out-of-doors in the observance and study of nature. If predatory birds were missing from nature, a very great loss to this group of people would result, as the hawks and owls, because of their size, majestic flight, or conspicuousness, are always of profound interest.

A movement has been on foot for several years to set aside parks and sanctuaries all over the country for the conservation of wild life. It is very desirable on these areas to conserve all the wild life, hawks and owls as well as the rest, so as to leave nature as little disturbed as possible. Nature may be best appreciated and enjoyed by man when it is in as nearly as possible an undisturbed condition. One of the purposes of these areas is to furnish cultural centers to teach man to enjoy to a large degree the natural and undefiled out-of-doors. However, such areas are not always easily accessible to everyone. It is desirable that this conservation be supplemented nearer home. The conservation of the hawks and owls would be one item in such a program.

ABUNDANCE OF HAWKS IN OHIO.

Before ascertaining the food habits of the various species of hawks and owls, it is necessary to consider their abundance in Ohio. This is necessary for any satisfactory judgment of their economic importance. In order to determine the abundance of the various species, resource was had to correspondence with thirty-six ornithologists in the State. A request was made of each observer to compile the number of times he had observed each species each year and then to total the entire number of times he had observed each species for all the years of his observation. Data were also obtained on the number of trips taken by each observer, the number of hours spent in observation, and the total mileage covered.

Twenty people replied to these requests with data and notes. Their names are listed below with the counties in which they made their observations.

Milton B. Trautman—All counties in State, particularly Fairfield, Licking, Pickaway, Perry, Franklin, Ottawa and Pike, 1922–1932.

LAWRENCE E. HICKS—All counties of State, 1918–1931.
S. V. WHARRAM—Ashtabula County, 1921–1931.
CLEVELAND BIRD CLUB—Geauga, Lake, Cuyahoga, Lorain, Erie and Ottawa Counties, 1931.
JOHN W. ALDRICH—Notes.
S. CHARLES KENDEIGH—Lorain, Erie, Ottawa Counties, 1920–1930.
LOUIS W. CAMPBELL—Lucas County, 1926–1931.
JIM A. BRUCE—Wayne County, 1928–1931.
EDWIN LINCOLN MOSELEY—Notes.
PAUL A. STEWART—Columbiana and Mahoning Counties, 1927–1931.
MERIT B. SKAGGS—Trumbull and Mahoning Counties, 1922–1932.
WM. C. BAKER—Columbiana and Mahoning Counties, 1929–1932.
E. V. PRIOR—Licking County, 1927–1932.
R. B. GORDON—Franklin County, 1921–1930.
MARGARET M. NICE—Franklin County, 1928–1931.
FLOYD B. CHAPMAN—Franklin, Fairfield, Licking, Hocking, and Delaware Counties, 1924–1932.
PAUL FORSTHOEFEL—Mercer County, 1925–1932.
BEN J. BLINCOE—Montgomery, Green and Miami Counties, 1923–1931.
WM. C. HERMAN—Notes.
CONRAD ROTH—Scioto and Adams Counties, 1926–1931.

The southern and southeastern parts of the State are not so well covered as the rest, but since two observers have studied in all the counties in the State while the other observers are fairly well scattered over the State, one is justified in believing that the relative abundance of the species, as given below, is representative.

A compilation of all the records sent in by the observers was made. These records are from seventeen observers covering the years 1918 to 1932. The total number of trips after birds taken by these ornithologists during this period was 6,902; the total number of hours spent in the field in observation was 39,095; while the total mileage covered was 180,142. The size of these totals is impressive, and since they were made by the best trained people in the state for the careful and exact identification of birds, they have considerable value.

In Table I, the number of times which each species of hawk was observed and its relative abundance are expressed.

Almost exactly half of all the hawks observed were sparrow hawks. This species was by far the most common one. The marsh hawk ranks next, followed by the red-shouldered and red-tailed hawks. These species are all decidedly beneficial to the farmer and sportsman. From the economic standpoint, more complaints have been lodged against the Cooper's, sharp-shinned, pigeon, duck, and goshawks than against any of the

others. Yet these five species together make up only 8.7% of the entire hawk population in the State. The other 91.3% of the hawk population is made up of species generally recognized by scientists to be beneficial. In other words, there are in the state of Ohio, over ten recognized beneficial hawks to every one that may be considered less desirable. The good done by the ten overbalances by far the harm done by the one, and gives a clear indication of the great economic importance of hawks to the farmer and sportsman in Ohio.

TABLE I.

RELATIVE ABUNDANCE OF HAWKS IN OHIO.

Species	Number of Times Recorded	Percent of Total Number Hawks Recorded
1. Sparrow Hawk	10,913	50 5%
2. Marsh Hawk	3,918	18 2
3. Red-tailed Hawk	1,946	9.0
4. Red-shouldered Hawk	1,640	7.6
5. Cooper's Hawk	1,168	5 4
6. Sharp-shinned Hawk	498	2.3
7. Broad-winged Hawk	369	1 7
8. Osprey	351	1 6
9. Bald Eagle	351	1.6
10. Rough-legged Hawk	272	1.3
11. Pigeon Hawk	86	0 4
12. Duck Hawk	57	0.3
13. Goshawk	32	0.1
14. Golden Eagle	5	0.02
Total	21,606	

ABUNDANCE OF VULTURES IN OHIO.

The turkey vulture and black vulture are sometimes mistaken for hawks by the uninformed. Both species are scavengers, living chiefly on dead and decaying matter, and so are of no harm to either the farmer or sportsman.

On the basis of the bird census described above, 25,703 turkey vultures and 357 black vultures were reported for the same period of time and over the same territory as were the hawks observed. The combined total of all species of hawks observed was 21,606, which is more than four thousand *less* than the number of times that the turkey vulture alone was observed. This beneficial species is a very important one, therefore, in a consideration of the bird life of Ohio. The black

vulture is far less common and confined entirely to the southern part of the State. The turkey vulture is also more common southward although generally distributed over the State.

ABUNDANCE OF OWLS IN OHIO.

Owls are much more difficult to locate and observe than are the hawks and vultures. In the census reports from seventeen observers which was described above, a combined total for all species amounting to only 3,585 individuals was observed, (Table II).

TABLE II.

RELATIVE ABUNDANCE OF OWLS IN OHIO.

Species	Number of Times Recorded	Percent of Total Number Owls Recorded
1. Screech Owl	1,672	46 6%
2. Barn Owl	558	15.5
3. Great Horned Owl	517	14 4
4. Barred Owl	450	12 6
5. Short-eared Owl	284	7.9
6. Long-eared Owl	52	1.5
7. Snowy Owl	28	0.8
8. Saw-whet Owl	24	0 7
Total	3,585	

The screech owl is by far the most abundant, the barn owl comes next, then the great horned owl and barred owl. The great horned owl which is sometimes destructive to poultry and game animals makes up only 14.4% of the total owl population. The other species are generally to be rated beneficial. Their combined total amounts to 85.6%. Thus, there are nearly six beneficial owls to each one that may sometimes be destructive. The economic status of the general owl population must be rated high.

FOOD HABITS.

Considerable study has been made by the Biological Survey, Department of Agriculture, Washington, D. C., and others, of the food habits of the various species of hawks and owls in the United States. Only when one knows the kind of food upon which the various species of hawks and owls feed, can one properly judge their exact economic importance. An attempt

has been made to summarize the available information on the nature of the stomach contents of all the species of hawks and owls that occur in Ohio, (Warren, 1890; Fisher, 1893).

TABLE III.

TYPES OF FOOD CONSUMED BY VARIOUS SPECIES OF HAWKS AND OWLS.

TURKEY VULTURE AND BLACK VULTURE.

Henderson (1927) states that these species feed chiefly on carrion. The turkey vulture also takes some snakes, toads, rats, mice, and occasionally young birds.

MARSH HAWK.

Stomachs examined—144.

Mice and other small mammals	54.9%
Small birds	23 6
Insects	9 7
Reptiles and batrachians	6.2
Poultry and game birds	4.9
Indeterminate	0.7

SHARP-SHINNED HAWK.

Stomachs examined—116.

Small birds	85 3%
Poultry and game birds	5.2
Mice and other small mammals	5.2
Insects	4 3

COOPER'S HAWK.

Stomachs examined—103.

Small birds	50.5%
Poultry and game birds	33.0
Mice and other small mammals	10.7
Lizards	2.9
Insects	1.9
Frogs	0.1

GOSHAWK.

Stomachs examined—25.

Mice and other small mammals	40.0%
Poultry and game birds	36.0
Insects	12.0
Small birds	8.0
Centipeds	4.0

RED-SHOULDERED HAWK.

Stomachs examined—398.

Mice and other small mammals	47.5%
Insects	23.1
Reptiles and batrachians	17.6
Spiders	4.0
Small birds	3.0
Crayfish	1 7
Fish	1.5
Poultry and game birds	0.7
Offal	0.5
Earthworms	0.2

RED-TAILED HAWK.

Stomachs examined—792.

Mice and other small mammals	69 6%
Poultry and game birds	9.0
Small birds	7 2
Insects	5.9
Reptiles and batrachians	5.0
Offal	0.2
Crayfish	0.1

BROAD-WINGED HAWK.

Stomachs examined—102.

Mice and other small mammals	31 4%
Insects	29 4
Reptiles and batrachians	27.4
Small birds	4.9
Crayfish	4 9
Earthworms	2 0

ROUGH-LEGGED HAWK.

Stomachs examined—58.

Mice and other small mammals	96.5%
Insects	1.7
Reptiles and batrachians	1.7

DUCK HAWK.

Stomachs examined—20.

Small birds	50.0%
Poultry and game birds	35.0
Insects	10.0
Mice and other small mammals	5.0

PIGEON HAWK.

Stomachs examined—61.

Small birds	67.2%
Insects	26.2
Mice and other small mammals	3.8
Poultry and game birds	3.8

GOLDEN EAGLE.

Stomachs examined—5.

Mice and other small mammals	40.0%
Carrion	40.0
Birds	20.0

BALD EAGLE.

Stomachs examined—17.

Fish	52.9%
Mice and other small mammals	29.4
Carrion	11 8
Game birds and poultry	5.9

TABLE III—[*Continued*]

TYPES OF FOOD CONSUMED BY VARIOUS SPECIES OF HAWKS AND OWLS.

SPARROW HAWK.

Stomachs examined—476.

Insects	50 2%
Mice and other small mammals	25.4
Small birds	13.0
Spiders	6 1
Reptiles and batrachians	2 5
Game birds	0 2

OSPREY.

Stomachs examined—11.

Fish	100 0%

BARN OWL.

Stomachs examined—47.

Mice and other small mammals	83 0%
Insects	8 5
Small birds	8 5

Pellets examined (*)

Number of skulls identified from Ohio—8,672

Mice and other small mammals	98 7%
Small birds	1.3

LONG-EARED OWL.

Stomachs examined—129.

Mice and other small mammals	86 0%
Small birds	11.6
Insects	1 6
Poultry and game birds	0 8

Pellets examined (†)

Number of skulls identified—88

Mice and other small mammals	95 7%
Small birds	4.3

GREAT HORNED OWL.

Stomachs Examined—134.

Mice and other small mammals	62.0%
Poultry and game birds	23.1
Insects	7.5
Small birds	6 0
Fish	0.7
Scorpions	0.7

SHORT-EARED OWL.

Stomachs examined—114.

Mice and other small mammals	83 3%
Small birds	10.5
Insects	6 1

BARRED OWL.

Stomachs examined—122.

Mice and other small mammals	56 5%
Insects	11 5
Small birds	11.5
Crayfish	7.4
Poultry and game birds	5 7
Frogs	3.3
Fish	1 6
Spiders	1.6
Lizards	0 8

SAW-WHET OWL.

Stomachs examined—26.

Mice and other small mammals	73.0%
Insects	23.1
Sparrows	3.8

SCREECH OWL.

Stomachs examined—300.

Mice and other small mammals	40 6%
Insects	34 0
Small birds	14 7
Crayfish	3 0
Miscellaneous	2.3
Reptiles and batrachians	2.0
Spiders	1 7
Scorpions	0.7
Earthworms	0.7
Fish	0.3

SNOWY OWL.

Stomachs examined—26.

Mice and other small mammals	64.5%
Small birds	29 0
Game birds and poultry	6 5

*Examinations by Roscoe W. Franks and Arthur Stupka.
†Examinations by the Wheaton Club, of Columbus, Ohio.

FOOD CONSUMPTION.

After considering the food habits of the different species of hawks and owls it is useful to summarize these data for all hawks together and all owls together. This furnishes a better criterion as to the actual amounts and kinds of food consumed by all birds of prey in Ohio, and enables us to judge better the

economic status of our hawk and owl population taken as a whole. These summaries are given in Tables IV and V.

The percentages in these two tables were arrived at in the following way. It was desirous to determine the percentage of each type of food in the total amount consumed by all hawks and by all owls in the State. In order to arrive at such figures, the relative abundance of each species (Tables I and II) had to be considered so that the types of food consumed by the more abundant species may carry proportionally more weight than the type of food consumed by the less common species. For instance, poultry and game birds make up 33.0% of the food of the Cooper's hawk, but the Cooper's hawk constitutes only 5.4% of the entire hawk population, so multiplying these two figures together and dividing by 100 gives 1.8% as the actual proportion of the entire food consumption of all hawks which this food habit of the Cooper's hawk represents.

Then again, mice and other small mammals make up only 25.4% of the food of the sparrow hawk. This is however, the most abundant hawk in the State (50.5%), so this food habit of this single species amounts to 12.8% of all the food consumed by all the hawks in the State. When these percentages are worked out for each type of food and for each species, the total combined results occur as given in the following two tables (IV and V).

TABLE IV.

Analysis of Total Food Consumption by All Hawks in Ohio.

Mice and other small mammals	35.7%
Insects	30 3
Small birds	16.9
Poultry and game birds	4.8
Reptiles and batrachians	4.8
Fish	2 6
Centipeds, offal, crayfish, spiders, scorpions, earthworms, and indeterminate	4.0

TABLE V.

Analysis of Total Food Consumption by All Owls in Ohio.

Mice and other small mammals	57.3%
Insects	20.4
Small birds	12.0
Poultry and game birds	4.1
Reptiles, amphibia, centipeds, crayfish, spiders, scorpions, earthworms, offal, fish, and miscellaneous	7.0

In looking over the records of stomach examinations for the various species in Table III, one may be inclined to conclude

that the Cooper's hawk, sharp-shinned hawk, goshawk, duck hawk, and pigeon hawk are very destructive predators, but when the food habits of the hawks, as a group, are studied with relation to their relative abundance, as in Table IV, we find that the amount of poultry and game birds eaten make up only a very small fraction (4.8%) of the diet. This fact is more sharply emphasized in the food studies of the owls. In this group the great horned owl does more damage than all the other species of owls combined, yet only 4.1% of the entire food of all the owls consists of game birds and poultry. We may charge up to the hawks and owls the 4.8% and 4.1% respectively of their diet taken from the supply of game birds and poultry, but we must also credit them with taking 66.0% and 77.7% respectively of their diet from our abundant supply of insects, mice, and other small rodents.

The insects eaten by the predaceous birds consist largely of grasshoppers and other large vegetarian forms and for this reason are placed on the credit side of the ledger of these birds.

The hawks and owls make up 16.9% and 12.0%, respectively, of their diet from small birds which are primarily seed and insect eating forms. This, in itself, is not of as great significance as may, at first, appear. The economic status of our smaller birds is not clearly known, because the relative value of the different kinds of food consumed is not well established. Do the insectivorous birds feed more on harmful forms of insects than on beneficial forms? Are they selective in their feeding habits? Do they avoid or destroy parasitic insects which are probably even more potent than are birds in holding the insect population in check? Undoubtedly, seed-eating birds consume immense numbers of weed seeds each year and act as one environmental agent in the balance of nature. However, are not natural competition among the weeds and plants themselves, together with climatic conditions, more potent factors in determining their abundance? Probably few of our small birds are entirely beneficial or entirely harmful in their food habits.

The food habits of some of the mice and other small rodents should be given careful consideration. If the feeding habits of these animals preyed upon by the predacious birds were wholly beneficial to man, then the birds of prey would be undesirable citizens. However, almost without exception, the

entire supply of food consumed by the mice and other small rodents is a direct loss to man. The field mice are abundant throughout the world and subsist upon field crops where they are available.

In the United States Department of Agriculture Year Book, 1917, we find the value of crops destroyed annually by rodents in the United States was estimated to be in excess of $150,000,000. This does not include the losses inflicted by house mice and common brown rats. In the same report we find the damage done in the State of Montana ran between fifteen and twenty million dollars, in Kansas twelve million, in North Dakota from six to nine million, and in California twenty million. In Wyoming, fifteen percent of all crops were destroyed by rodents. If the crops destroyed by rodents could be sold on the market, the return from this source would be sufficient to pay all the farmers' taxes.

Laboratory experiments by Bailey, 1924, reveal that the short-tailed field mice will eat on an average an amount per day equivalent to 107% of their own body weight when fed grass, clover, and cantaloupe rinds. Taking the average body weight of this species at thirty grams, Bailey figures that it will require 10,950 grams (23 pounds) of green food to feed each field mouse one year. He also states that 2,300 pounds of green grass or clover will produce one half ton of dry hay.

With these figures as a basis, we can arrive at the actual value of barn owls to agriculture. One pair of barn owls nesting in a sycamore tree came to the writers' attention February 13, 1927. Pelletts regurgitated in this tree were collected regularly over a period of two months time and their contents identified. During this time 518 mouse and shrew skulls and three sparrow skulls were left by the two owls. On this basis it would be conservative to say that one pair of barn owls will kill on an average 3,000 mice per year.

Using Bailey's figures for the amount of food consumed by field mice, we find three thousand mice would destroy 69,000 pounds of green feed per year, and that 69,000 pounds of green grass or clover is equivalent to 15 tons of dry hay. Assuming that one-half of this is of value to the farmer, the potential value of a single pair of barn owls is equivalent to 7½ tons of hay per year. Hay is worth on an average about $10.00 per ton. Therefore, the potential value of a pair of barn owls to agriculture is $75.00 per year.

Rodents are also among the worst pests with which the sportsman has to deal. Rodents destroy the eggs and young of game birds (Stoddard, 1931, p. 424).

The potential rate of reproduction of the field mouse is extremely high, and under favorable conditions the numbers may soon reach the state of a plague. Bailey's laboratory experiments clearly demonstrated this fact. He found that the first litter may come when the female is forty-five days old, and that the gestation period is twenty-one days. There are usually four young in the first litter, but six to eight in later ones. One female in captivity raised seventeen litters in one year, including 83 young, and remained in normal health. If all the progeny should live and reproduce at the same rate, one million individuals would be produced in one year. Under ordinary circumstances in a state of nature, the young do not all live. Nevertheless, when natural checks were removed, there have been many serious mouse plagues in this country and in many foreign countries.

CONTROL OF RODENT PLAGUES.

A brief review of some of the more serious rodent plagues in the United States and in Great Britain will serve to indicate the extreme importance of the predatory birds in keeping the numbers of the smaller mammals within bounds.

If the natural and normal checks against too rapid multiplication of rodents are removed, great damage results. As an example of what might happen in Ohio, due to killing off the predatory birds, the recent outbreak of the common house mouse, *Mus musculus*, in Kern County, California, in January, 1927, may be described (Hall, 1927).

"At the source, the dry bed of Buena Vista Lake, the writer found as many as 17 mice per square yard over an area of many acres in extent in the kafir corn field. Computed from the counts made on the measured areas, one arrives at the startling number of 82,280 mice per acre. This gives 2,668 pounds of mice per acre, figuring that $33\frac{1}{3}$ house mice weigh one pound.

"Grain bins that I saw had literally thousands swarming about in them; haystacks sheltered nearly as many; and the fields, since they had not been grazed by domestic stock, sheltered millions more. In one grain bin 20 feet square, that was two-thirds full of sacked barley, it was computed that 3,520 mice were in sight at one time. These were on the surface of the grain, on rafters, and on the pole plates. Many times this number unquestionably were out of sight in and among the sacks of grain. At night, on the highway that passes along the

north shore of Buena Vista Lake, the illumination from the headlights of one's car revealed hundreds of live mice at any given instant."

"Actual damage that the mice were seen to do included the destruction of quantities of stored grain; the reduction of large stacks of hay (really straw stacks that are here used for hay) to mere piles of chaff, thus rendering them totally unfit for stock food; the destruction of foodstuffs, clothing, bedding, linen, etc., in the houses; and the gnawing of holes through the floors and walls of frame buildings. It seems probable that the mice would damage growing crops although certainly not to the extent that equal numbers of meadow mice (*Microtus*) would. The house mice constitute a general nuisance on numerous counts. Many people have a general horror, on no specific grounds, of such vast hordes of mice . . . Where large numbers of mice congregate, as in grain bins and haystacks, the stench arising from the voided body excrements is highly offensive and nauseates many persons. In one observed instance a laborer working at a haystack was so nauseated by the stench from the mice as to vomit severely. In buildings that are not mouse-proof, persons commonly have their sleep interrupted by the numbers of mice that run about over the bedding. On arising in the morning mice are not infrequently found in one's clothing and shoes. During the day, even, when going about ordinary tasks, mice on occasion enter one's clothing. All these things, together with the actual damage done by the mice, naturally have caused considerable concern among the people living in the infested area."

"Hawks, owls, and ravens were more abundant here than usual, due to a movement into the infested area. . . . Named in order of their abundance from first to last, the hawks noted were: Marsh Hawk (*Circus hudsonius*), Western Red-tailed Hawk (*Buteo borealis calurus*), Desert Sparrow Hawk (*Falco sparverius phalaena*), and a rough-legged hawk (*Archibuteo*, sp.?). Barn Owls (*Tyto pratincola*) were abundant, and Short-eared Owls (*Asio flammeus*) were seen wherever there was terrestrial cover, a condition that obtained only at the western end of the lake. . . . Ravens (*Corvus corax sinuatus*) were present in flocks of 15 to 40 and fed on the mice. . . . Although predatory birds were abundant, predatory mammals were extremely rare in the infested area."

Other severe mouse plagues have occurred in various regions. In 1907–08, in Humboldt Valley, Nevada, there was an outbreak of field mice (*Microtus montanus*) that did considerable damage (Piper, 1909). Here it was estimated that there were from 8,000 to 12,000 short-tailed field mice to each acre. The fields were riddled by their burrows which were scarcely a step apart and over a large area averaged 150 to 175 to the square rod. The Humboldt Valley is occupied by a number of large ranches. At the time the plague began there were about 20,000 acres in alfalfa. Within a year and a

half of that time more than 16,000 acres had been destroyed by the mice. This loss to the farmers in the one valley alone amounted to $300,000 in two seasons. This serious plague was finally checked by the natural enemies of the rodents and by poison.

The striking evidence of the valuable services of the natural enemies of mice seen during this plague is but an example of their constant value. Hawks, owls, gulls, crows, ravens, herons, and shrikes among the birds, and coons, coyotes, foxes, weasels, badgers, and wildcats among the mammals, habitually prey upon field mice and are most valuable in preventing undue increase of these pests. In the Nevada valleys all species of hawks and owls are distinctly beneficial, and their rigorous protection has been strongly advocated.

In the report of the 16th American Game Conference (1929) we find that there has been a bounty on owls and hawks in Virginia for twenty years, and along with the depletion of the birds of prey there has been a corresponding increase in pine and short-tailed field mice. These mice are now so abundant in the Virginia orchards and nurseries that they have become an irresistible scourge and each year are wiping out many fortunes and making orcharding impossible in that State. Quoting from Dr. A. K. Fisher, "They are paying out a large sum to protect a potential thousand dollars of game, and probably losing several millions of dollars worth of agriculture."

Mr. Max Hart, secretary of the Virginia Game and Fish Commission, while speaking before the last American Game Conference (1931) hit the keynote with reference to vermin control. Referring to Virginia, Mr. Hart says that in the past ten years we have spent $200,000 on vermin control, but we have just about reached the conclusion that we have got to take that money that we are paying for vermin and buy game birds with it, and put them back in the fields and stop paying bounties on birds of prey. With all of their campaigning against "vermin," the Virginians have learned that killing off hawks and owls will not bring back the game birds.

A perfect example of what constant trapping of all predatory birds and mammals will do by way of removing all checks on the increase of field mice, can be seen on our own State game farm at Wellington, Ohio. On this farm a rigid and extensive campaign of trapping and shooting hawks and

owls is maintained throughout the year without regard or knowledge of the species taken. The game keeper's report to the Division of Conservation made on January 15, 1930, reveals that from March 1, 1929, to the date of the report, 213 hawks and 171 owls were killed on the farm. It is not likely that this number of predatory birds was attracted to the game farm by the game birds that were there, but by the countless thousands of field mice, with which the farm was literally teeming. A walk across the fields revealed the most abundant supply of these rodents ever seen by the writers. Mice could be seen almost constantly as they ran from under foot.

The game keepers of Great Britain are responsible for practically exterminating the hawks and owls on the islands (Adair, 1893; Maxwell, 1893; Middleton, 1930). Due to the almost total absence of predatory animals, Great Britain's vole plagues have been gradually and rapidly increasing for the past thirty years. During 1929 there were eleven major plagues scattered throughout the Islands.

The good work of the hawks and owls in destroying insects, mice, and other small rodents does not consist of breaking up plagues of these forms after they are once beyond control, but by the prevention of plagues arising, by the killing of millions of individuals long before the plague stages begin to threaten.

Here in Ohio we can well afford to spare an occasional game bird or chicken, if need be, to prevent rodent plagues such as occur every four years in Great Britain.

CONTROL MEASURES.

The above information shows clearly that the general hawk and owl population in Ohio have beneficial food habits and are powerful agents in the natural control of rodents. It is not best to distinguish too closely between species, because they all exert some important, controlling influence in nature, and the average person is not able to identify the different forms nor able to properly judge between the beneficial and harmful species. It is rather best to pass judgment on the hawk population as a whole and the owl population as a whole and base our state control measures upon whole populations rather than on each species separately.

If a general campaign against all hawks and owls were undertaken, the average person unable to discriminate between

species would very probably destroy ten beneficial hawks to one harmful one, nearly six beneficial owls to one harmful one, and would probably destroy as many beneficial vultures (if he could come within gun range) as he would all the hawks and owls together. Since the hawk and owl population is predominantly beneficial, such a general campaign should be made legally impossible.

As an illustration of the type of results that are obtained when state-wide eradication is attempted of some species and not others, the recent experience of Pennsylvania in 1929 may be cited. A bounty law was passed providing $5.00 on all goshawks taken in the State. Within one year after the law went into effect, 503 birds were taken into the office of the Pennsylvania Game Commission at Harrisburg in order to secure the $5.00 bounty. Out of this 503 birds only 76, or 15%, were goshawks. Over 58% of all the birds taken were of beneficial varieties.

TABLE VI.

Species and Number of Individuals Killed in State-wide Eradication Campaign Against the Goshawk in Pennsylvania.

Red-tailed Hawk	165
Cooper's Hawk	120
Red-shouldered Hawk	84
Goshawk	76
Marsh Hawk	28
Sharp-shinned Hawk	9
Rough-legged Hawk	7
Sparrow Hawk	4
Broad-winged Hawk	3
Duck Hawk	3
Pigeon Hawk	1
Osprey	1
Short-eared Owl	1
Great Horned Owl	1

Several years ago when a hawk law was in force in Ohio, the township clerk at Wakeman issued 86 bounty certificates. Of these 86 hawks killed, 46, or 53.5%, were sparrow hawks, which is a very beneficial species (Fisher, 1907, p. 9). This is to be expected in indiscriminate shooting of hawks, since our census indicates that 50.5% of all hawks which one may meet in the field belong to this species. Such activities soon bring species on the verge of extinction, with the resulting dangers from rodent plagues. Control measures designed to eliminate certain species and not others are distinctly and unquestionably *inadvisable.*

Certain states, notably Pennsylvania, have undertaken in bygone times state-wide campaigns for the eradication of hawks and owls. The great economic loss which these campaigns have meant to the state is well summarized in the Report of the Commissioner of Agriculture for 1886 (Merriam, 1887):

"On the 23d of June, 1885, the legislature of Pennsylvania passed an act known as the 'scalp act,' ostensibly 'for the benefit of agriculture,' which provides a bounty of fifty cents each on Hawks, Owls, Weasels, and Minks killed within the limits of the State, and a fee of 20 cents to the notary or justice taking the affidavit.

"By virtue of the act about $90,000 has been paid in bounties during the year and a half that has elapsed since the law went into effect. This represents the destruction of at least 128,571 of the above mentioned animals, most of which were Hawks and Owls.

"Granting that five thousand chickens are killed annually in Pennsylvania by Hawks and Owls, and that they are worth 25 cents each (a liberal estimate in view of the fact that a large proportion of them are killed when very young), the total loss would be $1,250, and the poultry killed in a year and a half would be worth $1,875. Hence it appears that during the past eighteen months the State of Pennsylvania has expended $90,000 to save its farmers a loss of $1,875. But this estimate by no means represents the actual loss to the farmer and taxpayer of the State. It is within bounds to say that in the course of a year every Hawk and Owl destroys at least one thousand mice, or their equivalent in insects, and each mouse or its equivalent so destroyed would cause the farmer a loss of two cents per annum. Therefore, omitting all reference to the enormous increase in the numbers of these noxious animals when nature's means of holding them in check has been removed, the lowest possible estimate of the value to the farmer of each Hawk, Owl and Weasel would be $20 a year, or $30 in a year and a half."

"Hence in addition to the $90,000 actually expended by the State in destroying 128,571 of its benefactors, it has incurred a loss to its agricultural interests of at least $3,857,130, or a total loss of $3,947,130 in a year and a half, which is at the rate of $2,631,420 per annum! In other words, the State has thrown away $2,105 for every dollar saved! And even this does not represent fairly the full loss, for the slaughter of such a vast amount of predaceous birds and mammals is almost certain to be followed by a correspondingly enormous increase in the numbers of mice and insects formerly held in check by them, and it will take many years to restore the balance thus blindly destroyed through ignorance of the economic relations of our common birds and mammals."

It is conceivable that locally on game farms, in poultry yards, and similar places, a certain amount of protection against preying individuals of some species of hawks and owls may be necessary. Individual birds occasionally acquire

devastating habits, and their elimination is justified. One must make sure, however, that hawks visiting poultry yards are not after rats and mice rather than chickens. Such few individuals, however, by no means condemn the species as a whole nor warrant general campaigns of eradication.

In the protection of local areas, care must be taken in selecting the proper method of defense. Poisoned bait is not recommended because of the great danger to which it exposes other species.

Likewise, the pole-trap is distinctly not advised because it does not distinguish between individual birds bent on destruction from others. Wight (1931) discusses the use of pole-traps on state game refuges in Michigan and shows clearly that they are much more detrimental to beneficial species, including many of the smaller song birds, than they are to the few harmful species of hawks and owls.

Some other method should be used as a control measure. Probably the use of the shotgun on hawks and owls caught in the act of stealing is the safest and best method.

CONSERVATION MEASURES.

In 1928, Hadley reported on the legal status of hawks and owls in the United States at large. Thirty-four states at that time gave some protection to hawks and owls, usually discriminating between species that were sometimes harmful and those which were beneficial. In an attempt to determine how effectively these laws were enforced, Hadley sent a questionnaire to the game commissioners in each state. The general consensus of opinion was that these laws were unenforceable, particularly when it came to protecting some species and not others.

In view of the difficulty of the average person in distinguishing between the various species, a law giving protection to some species and not to others is impracticable and impossible to enforce. The solution is, of course, to create a law giving the same consideration to all species equally. If a study of all the hawks and owls over the State should show that they are predominantly harmful, no protection needs to be offered any species. If, on the other hand, such a study should show that they are predominately useful, then it is best to give equal protection to all. This study indicates strongly that the latter condition is the true one.

The conclusion is warranted, therefore, that the state legislature is amply justified, on the basis of scientific data available, to adopt a law giving rigid protection to all hawks and owls over the State. A clause may be inserted in such a law permitting special control against devastating hawks or owls in local regions, but eliminate, entirely, all possibility of general state-wide campaigns for destruction.

BIBLIOGRAPHY.

The following references to literature dealing with hawks and owls by no means include all that are available, but represent significant and important contributions with which students of conservation should be familiar.

Adair, Peter. 1893. Notes on the disappearance of the short-tailed field vole (*Arvicola agrestis*), and on some of the effects of the visitation. The Annals of Scottish Natural History, Vol. 2.

American Game Protective Association. 1929. Transactions of the sixteenth American Game Conference. New York.

1931. Transactions of the eighteenth American Game Conference. New York.

Bailey, Vernon. 1924. Breeding, feeding, and other life habits of meadow mice (Microtus). Journal of Agricultural Research, Vol. 27, No. 8.

Hadley, Alden H. 1928. The legal status of hawks and owls: a statistical study. Transactions of the Fifteenth National Game Conference.

Hall, E. Raymond. 1927. An outbreak of house mice in Kern County, California. University of California. Publications in Zoology, Vol. 30, No. 7, pp. 189–203.

Hausman, Leon Augustus. 1927. The hawks of New Jersey and their relation to agriculture. Bulletin 439, New Jersey Agricultural Experiment Station, New Brunswick, N. J.

Henderson, Junius. 1927. The practical value of birds. New York.

Fisher, A. K. 1893. The hawks and owls of the United States in their relation to agriculture. Bulletin No. 3, Division of Ornithology and Mammalogy, U. S. Department of Agriculture.

1907. Hawks and owls from the standpoint of the farmer. Circular No. 61, Biological Survey, U. S. Department of Agriculture.

Kirkpatrick, John. 1859. The rapacious birds of Ohio. Ohio Agriculturist, Report for 1858, pp. 340–383.

Maxwell, Herbert Eustis (Chairman of committee). 1893. Report of the plague of field-voles in Scotland. The Annals of Scottish Natural History, Vol. 2, No. 7.

McAtee, W. L. 1931. A little essay on vermin. Bird-Lore, Nov.-Dec.

Merriam, C. Hart. 1887. Report of the commissioner of agriculture, 1886. U. S. Department of Agriculture.

Middleton, A. D. 1930. Cycles in the numbers of British voles. Journal of Ecology, Vol. 18.

Pearson, T. Gilbert. 1929. The case of the hawk. Circular No. 17, National Association of Audubon Societies.

Piper, Stanley E. 1909. The Nevada mouse plague of 1907–08. Farmer's Bulletin 352. U. S. Department of Agriculture.

Preble, Edward A. 1927. A plea for our hawks. Nature magazine, January.

Quinn, Davis. 1929. "Framing" the birds of prey. New York.

Snyder, L. L. 1932. Hawks and Owls of Ontario. Handbook No. 2, Royal Ontario Museum, Toronto.

Stoddard, Herbert L. 1931. The bob-white quail. New York, 1931. Its habits, preservation and increase. Charles Scribner's Sons.

Stupka, Arthur. 1931. The dietary habits of barn owls. Bulletin No. 6, Bureau of Scientific Research, Division of Conservation, State of Ohio.

Sutton, George Miksch. 1925. A year's program for bird protection. Bulletin No. 7, Board of Game Commissioners, Commonwealth of Pennsylvania.

Trautman, M. B. and Wickliff, E. L. 1931. A key to the vultures, hawks, and eagles of Ohio, together with a brief description of their plumages and habits, and a summary of their economic status. Bulletin No. 5, Bureau of Scientific Research, Division of Conservation, State of Ohio.

Warren, B. H. 1890. Report on the birds of Pennsylvania with special reference to the food habits, based on over four thousand stomach examinations. Harrisburg.

Weed, Clarence M. and Dearborn, Ned. 1924. Birds in their relations to man. Philadelphia.

Wight, H. M. 1931. The effect of pole traps on harmless and beneficial species. The Wilson Bulletin, Vol. XLIII, No. 4, pp. 282–292.

Editor's Note.

It will be of interest to the readers of the above paper to note that the Ohio Academy of Science at its annual meeting in 1932 approved and accepted the following recommendation offered by the Committee on State Parks and Conservation:

"We believe that all persons interested in conservation of our wild life should rally to the support of our birds of prey. Due to popular prejudice resulting in indiscriminate persecution of all species, our birds of prey are rapidly decreasing in numbers, some species being threatened with extermination. The great majority of our predacious species have long since been proven to be beneficial in their food-habits, while the few species known to be more or less destructive are so reduced in numbers that any damage attributable to them is negligible.

We recommend that all birds of prey be protected by law, subject to the right of any citizen to control them when in the act of destroying his property.

We further believe that the pole-trap is a wasteful and inhuman means of capturing birds of prey, since it not only does not discriminate between injurious and beneficial species of predacious birds, but also destroys large numbers of song-birds and game mammals. We therefore recommend that legislation be enacted making use of the pole-trap illegal."

THE BLUE HOLE OF CASTALIA.

KARL VER STEEG AND GEORGE YUNCK,
College of Wooster.

INTRODUCTION.

The Blue Hole of Castalia, famed for its beauty and one of the scenic spots in Ohio, is located on the northern outskirts of the village of Castalia, seven miles southwest of Sandusky and about three miles from the Erie-Sandusky county line, which at one time marked the western boundary of the Connecticut Western Reserve.

The earliest historical record of the springs at Castalia is that in the report of Major Robert Rogers of New Hampshire.[1] After the fall of Quebec, Major Rogers left Montreal to take over the western forts held by the French and Indians. At Presque Isle he met Pontiac and was escorted to Detroit. Having secured the post at Detroit, Rogers returned by way of the Sandusky and Tuscarawas Trail which passed near the head of Cold Creek where the Castalia springs are located. In his observations of September 13, 1760, he remarks, "there is a remarkable spring at this place rising out of the side of a small hill with such force that it boils out of the ground in a column three feet high. I imagine it discharges ten hogsheads of water a minute."

This area was frequently occupied by the Ottawa and Wyandot Indians, the latter establishing a village on the present site of the town of Castalia. The springs furnished a plentiful supply of clear, cold water and Cold Creek leading from them, in its natural course, flooded much level land which was a paradise for muskrats, otter and mink. Deer and wild turkey were also numerous.

TOPOGRAPHY AND GLACIAL HISTORY.

In order that one may appreciate the geology of the area in which the Blue Hole is located, it is necessary to include the territory bounded by Sandusky Bay on the north, by

[1]Peeke, "History of Erie County," Lewis Publishing Company, Chicago, 1916.

parallel 41° 15′ north latitude on the south, and by meridians 82° 30′ and 83° W, essentially the area included within the Sandusky and Bellevue quadrangles.

The topography of this area, which lies wholly within the Erie Lake Plain of the central lowlands, is without any marked features. It is generally level and slopes gradually northward to Sandusky Bay which is considered the drowned pre-glacial channel of the Sandusky River. In pre-glacial time the Sandusky River flowed eastward past Johnson's Island to the trunk stream which is believed to have occupied the basin of Lake Erie and drained eastward from Detroit to Niagara.

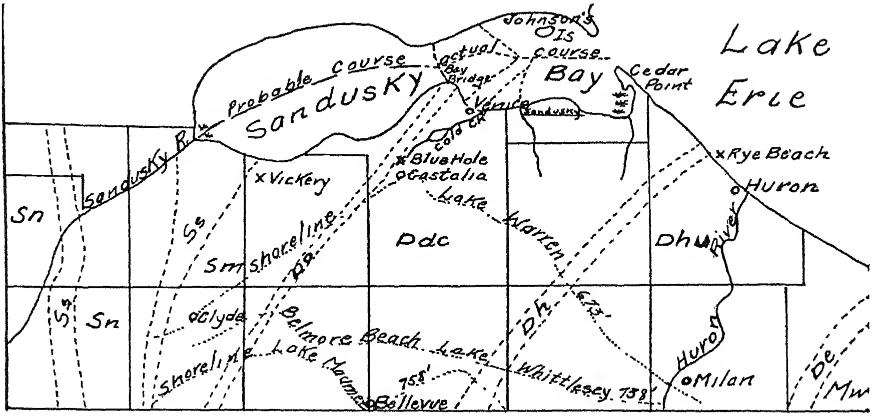

FIG. 1. Map of the Castalia area, showing formations, beach ridges and pre-glacial drainage. Legend: Niagara, Sn; Salina, Ss; Monroe, Sm; Oriskany, Do; Delaware and Columbus, Ddc; Hamilton, Dh; Huron, Dhu; Erie, De; Waverlyan, Mw.

Professor E. L. Mosely[2] has traced the course of the Sandusky River in the eastern half of the bay by means of auger drillings. Cold Creek, which obtains its supply of water from springs at Castalia now empties into Sandusky Bay at Venice, but originally continued in a northeasterly direction for two miles and joined Mill Creek which flowed into the old Sandusky River south of the western end of Johnson's Island.

South of Sandusky Bay the gently rolling, monotonous topography, characteristic of the prairie regions, has been produced by the planing action of glaciation and the expanded

[2]Mosely, E. L., "Formation of Sandusky Bay and Cedar Point," Ohio State Academy of Science, Vol. IV, Part V.

post-glacial lakes of Pleistocene time. As a result of glaciation, drift deposits of clay covered the region but these were largely removed by the post-glacial lakes. The withdrawal of the lake resulted in a fine, rich soil which is now covered by grass and sparsely timbered. The Castalia Blue Hole area is about one hundred and eighty feet above the level of Lake Erie, toward which consequent drainage is effected by numerous surface streams and the Huron River to the east. The absence of surface drainage is very noticeable in the limestone sink area, extending southwest of Castalia.

The history of the shrinking post-glacial lakes is readily determined by the old Lake beaches that roughly parallel the present Lake Erie from west to east. The first lake formed in the northeastward retreat of the Wisconsin glacier was Lake Maumee whose outlet was located at Fort Wayne, Indiana, through the Wabash and Mississippi rivers. This was the highest and oldest lake formed by the impounding of glacial water in front of the Labradorian ice sheet. The Maumee beach may be seen in the western part of Bellevue and the southeastern portion of Norwalk. It follows approximately the 750′ contour line and extends from the southeast corner of the area, three miles south of Clyde, through Bellevue and Norfolk. The next lowest beach parallels that of Lake Maumee at an altitude of about 738′ above sea level, one hundred and sixty-five feet higher than Lake Erie. The third and last beach in this area is that of Lake Warren, a lake of great size, the outlet of which was by way of Ubly, Michigan, Lake Chicago and the Illinois River. This beach is quite distinct and serves as the route for the Clyde-Castalia road or State Highway 101. It extends from Clyde in a northeasterly direction, a distance of fourteen miles to a point beyond Castalia, where it bends to the southeast toward Milan and Berlin Heights, parallel to the present shore of Lake Erie. Between the Lake Warren beach, one hundred feet above Lake Erie, northward to the shore of Sandusky Bay, the topography is flat and gently sloping. Castalia lies at the base of a limestone promontory that extended into the waters of Lake Warren. This position, at the base of a limestone drainage area to the south, is responsible for the outlet of the springs at Castalia and elsewhere to the west, such as the Rockwell Springs.

STRUCTURE.

Castalia is located on the Columbus limestone of Middle Devonian age which is underlain by the Monroe limestone of the Upper Silurian. All the formations of the area dip to the southeast at a low angle. Castalia stands on the eastern flank of the Cincinnati arch or geoanticline, near the axis, which bends to the east across Lake Erie into Ontario. In consequence of this dip the rock outcrops in Ohio are roughly arranged in north and south bands across the state. The rock outcrops in the Castalia area extend in a southwest-northeast direction, due to the curve of the axis of the Cincinnati arch. Early Waverlyan, or Lower Mississippian sediments appear on the east, followed by the Ohio shales of the Upper Devonian which are more than three hundred feet thick. Sandusky and Castalia are located on the Onandaga (Columbus and Delaware) limestone of Middle Devonian age which is underlain by the Monroe limestone of Upper Silurian (Cayugan) age. The Monroe limestone is a typical dolomite about one hundred feet thick and it is in this horizon as well as the Columbus and Delaware formations that the underground streams in the region about Castalia have carried on their work. The Cincinnati arch flattens out at its crest in western Ohio, in consequence of which the Monroe formation outcrops extensively. It is in this formation that the caves of west-central Ohio, at West Liberty and Zane were formed. Sink-hole topography is best developed in the Bellevue-Castalia area.

GENERAL DISCUSSION.

Caves and sink holes are characteristic of a limestone region. Prominent cave and sink-hole areas in the United States occur in north-central Florida, Virginia, and central Kentucky. The celebrated Mammoth Cave and the Luray Cave are large scale examples of the same processes which formed the underground passages near Castalia and the caves of Put-in-Bay, Ohio. The surface water with the aid of carbon dioxide and organic acids in solution, dissolves the limestone along every crack it penetrates and forms a connecting system of underground channels by which all drainage of the region is effected. In limestone areas streams may disappear beneath the surface and after flowing underground for great distances reappear, issuing forth as a stream or a

huge spring. Similar fountains occur in foreign countries, notably Greece where the classical Clitumnus burst forth at the base of a limestone mountain. This spring was famous for its cerulean blue water and was sacred to Apollo and the Muses.

A glance at the Sandusky and Bellevue topographic maps discloses the extensive development of underground drainage which has undermined the Columbus and Delaware limestone, causing it to slump into the cavities below, forming sink-holes. These are depressions with no outward drainage and surrounded by inward facing cliffs, formed when the roofs of the caves collapse. Perhaps the largest and most typical example in this area is located a mile south and east of Castalia, where a sink-hole includes several acres without surface inlet and faced by cliffs of rock still in their original position.

The sink-holes are concentrated south and southwest of Castalia toward Bellevue, nine miles to the south, and Clyde twelve miles to the southwest. The Silurian-Devonian contact (Monroe-Columbus) cuts diagonally across the Bellevue quadrangle from Bay Bridge on Sandusky Bay to the southwest corner of the Bellevue quadrangle, passing about a mile and a half east of Clyde. The Upper Devonian-Middle Devonian (Huron-Columbus) contact describes an arc from a point about two miles southeast of Bellevue to Rye Beach on Lake Erie. Between these limits is the outcrop of Delaware and Columbus limestone and the area of sink-hole distribution. Sink-holes do not appear on the Monroe outcrops to the west but numerous springs issue forth; those at Vickery are examples. To the south in Ohio, along the Silurian-Devonian contact, the writer did not find any sink-hole development comparable to that in the Bellevue quadrangle. The number of sinks decreases rapidly in Seneca County on the south but are numerous north and west of Bellevue. This city is known for its lack of a sewer system. The amount of sewer pipe is almost negligible, for all the inhabitants need to do is to drill a hole of sufficient depth in the Delaware and Columbus limestone through which all the sewage escapes and is carried away through subterranean channels. The popular concensus of opinion is that the outlet is unknown, that the source of the Blue Hole water has not been determined, and that the depth of the vivid blue water is limitless. Mosely introduced corks and cork dust into the sinks at Bellevue. These were looked

for by the residents of Castalia, but never found; they were doubtless filtered out as is most solid matter in ground water. Nevertheless, since the watershed slopes from Bellevue north to Sandusky Bay, the water coming from the springs in Castalia must obviously come from the south, according to geologic reasoning. During the heavy rainfall of the spring of 1913 which occasioned the Sandusky River floods, the amount of run-off was so great that the channels draining the Castalia-Bellevue area were filled beyond their capacity, resulting in the flooding of low places in Bellevue and the fields to the north by water which came forth from openings where normally it entered. In the spring of 1930 many acres were flooded and the Castalia-Bellevue road, four miles north of Bellevue was impassible. Here water, three to four feet deep, issued from the ground, where before and after no openings were discernible. What seems to be conclusive proof that the underground drainage is from Bellevue to Castalia, is supported by the results of investigations made by Dr. F. M. Houghtaling, Erie County Health Commissioner. He writes,[3] "Several years ago I was quite concerned about the water supply of the Blue Hole at Castalia and made repeated bacterial examinations and found nearly all deep water wells between Bellevue and Castalia and the flowing wells in the region of Vickery contained B-coli in sufficient numbers to make the water unsafe for domestic use. The waters of the Blue Hole will develop gas-forming bacilli within twenty-four hours with a high bacteria count when plated. As no doubt you are aware, there is no sewage disposal at Bellevue. It has been the custom for years to drill wells until the drill drops into a cavern, and then pull the tools and test it by putting a fire hose in for several hours. It was evident to me that this was the source of contamination. To prove my judgment I placed one pound of Uraline dye in a flush bowl in Bellevue. This colored the water definitely for a distance of three miles on the Bellevue-Castalia road. I had a faint reaction five miles from Bellevue and three miles from Castalia. I am satisfied that if I had used two or three pounds of dye I would have made the Blue Hole a bright green color. The expense stopped me from further experiment. When you consider the amount of water that this dye will color, and the distance in which the dilution

[3]Personal communication, 1932.

was so great that it faded out, proved to me that there is a large body of water under this area."

The Castalia springs are four in number and discharge into a pond a few acres in extent, located in the central and east portions of the village. About twenty-five thousand gallons of water are supplied to the pond per minute. This volume formerly flowed across the prairie on the north and through the marsh southeast of Bay Bridge by means of a stream, now extinct. This creek flowed northeast four miles from the shore of Sandusky Bay, at a point one and one-fifth miles east of Bay Bridge and joined the old Sandusky River a quarter of a mile upstream from Mill's Creek near Johnson's Island. With the advent of man, the prairie to the north and west of Castalia was too wet for trees. This area has been artificially drained by canals, leading the water north and northeastward into two branches of a creek flowing into the bay at Venice. The entire stream course has been known as Cold Creek.

The great marl beds used for cement by the Sandusky Portland Cement Company at Bay Bridge were formed in the flooded area north of Castalia, from the spring waters which contain a high percentage of calcium carbonate. The abundance of tufa at the surface makes it impossible to plow the land, which can be used for pasturage only. The marl bed area has always presented dismal agricultural prospects and it required little persuasion for the owners to sell their land to a "sporting club organization." Chemical analysis revealed the great value of the tufa deposits which are in demand for cement and other products. The tufa was formed by a plant known as the chara which grows in water containing carbonate of lime. This it takes from the water in which it lives; after it dies the resulting travertine becomes encrusted with the same substance, forming tufa. Travertine or tufa is composed of about 97% of calcium carbonate, 1% of magnesium carbonate, and lesser quantities of barium sulphate, aluminum, iron and silica. Willow Point, located half-way between Bay Bridge and the mouth of the Sandusky River is a gravel beach half a mile long, several yards wide and rising not more than three feet above the usual bay or lake level. The marsh back of the beach contains no tufa and therefore the pebbles must have been derived from the marl beds underlying and below the level of the bay. Marl is excavated by the Sandusky Portland Cement Company in

many places at a depth of five or more feet below the level of the bay. This is evidence that the lower reaches of the Sandusky River have been drowned producing an estuary, Sandusky Bay.

The Blue Hole is not more than one hundred and ten years old; it came into being about 1820 when the pressure caused by the rising of the water of the upper pond in Castalia, as the result of a dam, weakened the strata above the Blue Hole and occasioned its collapse into the cavernous depth. This dam was located in front of the church in the center of the village where the pond emptied into the outlet stream. The new spring has since had a sympathetic relationship with the larger and less beautiful pond to the south. Undermining has proceeded since the original collapse, for early in 1914 another cave-in occurred leaving the Blue Hole with its present dimensions, roughly circular, averaging seventy-five feet in diameter. The Blue Hole did not gain wide publicity until about 1879, because it was inaccessible except by boat. The organization of the Cold Creek Trout Club, brought about the banking of the marshy edges of the Blue Hole so that one could walk about the orifice. Today the area to the south and less to the east and west is still very moist and few trees of any size can grow there.

Contrary to prevalent belief, the depth of the Blue Hole is not unknown, but has been sounded and found to be about forty-three to forty-five feet deep. The deepest point is near the south margin, where on a sunny day one may follow the descent of a small object through the limpid water to the mysterious depths below. The sun must be shining in order to penetrate the depths, for the surface otherwise acts as a mirror. Therefore the summer time is the best season in which to fully appreciate the vast, quiet beauty of the Blue Hole. The surface remains undisturbed, even though there is a constant volume of water coming from below. About five thousand gallons of water per minute escapes from the Blue Hole, through two outlets, over artificial cascades made to aerate the water which is lacking in free oxygen. Trout cannot live in the Blue Hole because of the lack of free oxygen. The volume of water and its temperature remain remarkably constant throughout the year. Drought and rainfall show a slight influence; the flow is regulated beneath the surface in a manner comparable to the regulatory influence that a mantle

of trees and grass has over the surface drainage. During and after the drought of 1930 the Blue Hole showed no noticeable volume change. The temperature of the water does not vary appreciably during summer and winter; the maximum fluctuation is about 5° Fahr., that is from 46° to 51°. This fact, and the huge volume of water supplied by all the springs, prevents Cold Creek from freezing during the winter. Consequently, mills were established at an early date along the

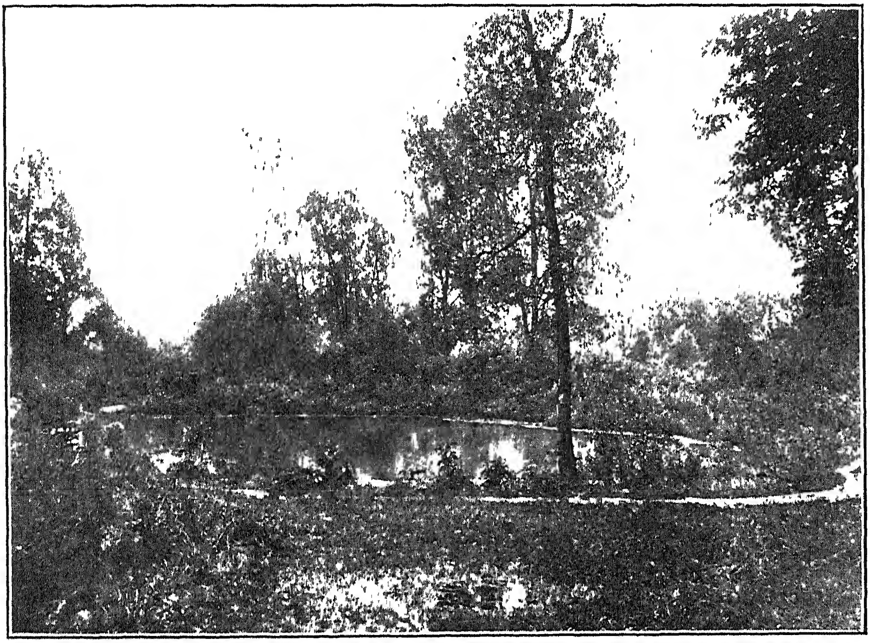

FIG. 2. The Blue Hole of Castalia.

five-mile length of Cold Creek to Sandusky Bay. The constant source of power throughout the year was of great value to the early pioneer.

The Blue Hole and other springs at Castalia send out thirty thousand gallons of water per minute into the canals which extend north a mile and a half to the club house of the Castalia Sporting Club, where they join in a single straight channel, the length of which extends an equal distance to the northeast. To this point the fall averages seven feet per mile and now descends by two cascades into a natural stream

course ten feet below. Here is the site of a stone mill which was originally built in 1839 and destroyed by fire in 1888. The ruins are now seventy feet from the cascades; in forty-five years the falls have retreated this distance. Castalia (640-650 feet) is approximately seventy feet above mean lake level (573 feet) and Cold Creek has a fall of fifty-seven feet to Gallagher's Mill at Venice where the only mill along the creek is located.

The Castalia springs at an early date attracted attention because of their cold water and constant flow throughout the year. Ideal conditions existed for the establishment of grist mills and many were built and operated during the past century. The village of Venice was founded at the mouth of Cold Creek in 1816 and became of increasing importance as a milling center. During the coldest winter ever recorded, Cold Creek was the only creek not to freeze over. All southern Michigan and northern Ohio were dependent on the Venice mill for the grinding of flour. During the dry summers when there was an insufficient supply of water to operate the mills the farmers brought their grain for great distances to the mill at Venice. Carp ponds now flourish at Venice; the cold water allows the fish to be kept healthy until ready for the eastern market. Distilleries, tanneries, paper mills and cotton mills have during the past one hundred and twenty years been established on Cold Creek and at Castalia because of the purity of the water, its low temperature and power. In 1868, Cold Creek was first stocked with speckled trout. It was not long until the Castalia Sporting Club was organized (1878). The next year the Cold Creek Trout Club originated. In 1887 the former reorganized as the Cold Creek Sporting Club and later again changed its name; this time to the present Castalia Trout Club whose club house is located just beyond the Blue Hole. Farther down stream is the "Lower Club" (Castalia Sporting Club). On the grounds of the younger club are twelve miles of trout stream supplied by a private hatchery located just east of the Blue Hole. German Brown Trout were once artificially propagated until it was discovered that they fed on the smaller trout. Nevertheless, this species still persists and on occasions some as large as eight pounds are caught. Rainbow and Steelhead trout are the other two species now stocked in the stream. Four to eight thousand fry are hatched every year and much care is taken to see that

the proper amount of food organisms are supplied to the growing fish. The Steelhead or Salmon trout were experimented with eight years ago by the Castalia Trout Club, but the fear that they would exterminate the other trout is the reason why the fry were freed in Sandusky Bay.[4] Lately fishermen have been catching seven, six and five year old Steelhead trout in Sandusky Bay, ranging up to twelve pounds in weight. This proves that this species of trout can spawn in these waters, probably opposite the mouths of the spring-fed streams that empty into the bay. Sandusky Bay is located, throughout its fifteen mile length, above the Monroe limestone from which cold springs well out under the bay and lower the temperature below that of Lake Erie, making it possible for Steelhead trout to multiply and provide sportsmen with a fighting game fish that is obtainable only in the Rogue River in Oregon. The full grown trout weigh twenty or more pounds. The State recently purchased a twelve acre area near Vickery; a huge volume of cold water from the springs there is ideal for fish propagation.

[4]Sadler, Webb, Member of Castalia Trout Club.

The Invertebrata.

For many years there has been a real need for a satisfactory one-volume text and reference work on invertebrate zoology—one that would embody the present-day knowledge of taxonomy, morphology, and phylogeny, and also emphasize the physiological and ecological aspects of the subject The first volume of Parker and Haswell's Textbook of Zoology, which thirty-five years ago admirably filled this need, has undergone but little change in its successive editions; and no other work of comparable scope and size has appeared. The present volume, the work of English zoologists and English printers, comes closer to meeting the demand than any other book published in recent years.

The book is well organized, and shows evidence of much careful, painstaking work. The classification adopted combines conservatism with the utilization of the general results of recent taxonomic work. The chief emphasis throughout is morphological. However, the treatment of the theoretical side of invertebrate morphology, which can be used to such good advantage to give coherence and add interest to this subject, is extremely limited. The discussion of evolution and phylogeny also seems inadequate, and sometimes lacking in understanding. Thus the statement, (p. 2), that ". . . . the Platyhelminthes or flatworms seem to be related to the annelid stock. Their lack of coelom is a difficulty in this respect."

The typography, in general, is good. The type used for the text is slightly smaller and more closely spaced than is usual in zoological textbooks, and many of the drawings are on a smaller scale than might be desired, and these things detract somewhat from the attractiveness of the printed pages. Most of the illustrations are simple, clear line drawings; many of them have not previously been seen in textbooks.—W. J. Kostir.

The Invertebrata: A Manual for the Use of Students, by L. A. Borradaile and F. A. Potts, with chapters by L. E. S. Eastham and J. T. Saunders. xiv+645 pp. 458 figs. New York, The Macmillan Company (Cambridge, England: At the University Press), 1932. $5.50.

STUDIES IN HUMAN INHERITANCE. IX.

The Inheritance of Taste Deficiency in Man.

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The establishment of linkage in man has long been one of the objectives in the writer's laboratory. To this end any unit character in man which occurs with reasonable frequency in the general population must be carefully analyzed and its unit-character nature established or disproven beyond question.

Among the most recently discovered of the unit characters in man is the so-called "taste blindness" or taste deficiency. The hereditary nature of this trait was established in 1931 by Snyder with 100 families, and by Blakeslee and Salmon with 47 families, following Fox's original discovery that taste deficiency actually existed. The final proof of the unit-character nature of any human hereditary factor, however, must lie in the mathematical analysis of the data, since we are unable to distinguish accurately between heterozygous and homozygous dominants in man. We are therefore unable in this particular instance to predict directly the ratios of tasters and non-tasters among the offspring of various matings.

Such predictions can be made, however, on a frequency basis. Since in our linkage studies it is essential for us to be certain of the unit-character nature of the taste deficiency, there is presented here the statistical analysis of the inheritance of taste deficiency among 800 families which have been studied at the Genetics Laboratories of the Ohio State University.

To Dr. Fox, of the DuPont Laboratories, we owe the accidental discovery that a small crystal of para-ethoxy-phenyl-thio-carbamide placed on the back of the tongue may produce one of two characteristic reactions. To some persons it will give an extremely bitter sensation, somewhat like quinine. To others no bitter taste at all will be apparent. The reaction is clear and distinct, and practically no doubtful cases are encountered. Since phenyl-thio-carbamide reacts the same as para-ethoxy-phenyl-thio-carbamide, we have used the former substance as being more readily available to us.

The results of our study of 800 families are given in Table I. It will be noted that the taste deficiency appears to be a simple

recessive character. Where neither parent tastes the compound, practically none of the children do. The small fraction of a percent exceptions may be due to illegitimacies, adoptions, errors in technic resulting from the fact that the phenomenon is a subjective one entirely, or to the possible taste-suppressing effect of some environmental agent of which we know nothing at present. We do know that acidity or alkalinity of the mouth, age, sex, and other tested variables apparently have no effect upon this taste deficiency.

TABLE I.

SUMMARY OF 800 FAMILIES STUDIED FOR INHERITANCE OF TASTE DEFICIENCY FOR PHENYL-THIO-CARBAMIDE, SHOWING OBSERVED AND CALCULATED PROPORTIONS OF TASTERS AND NON-TASTERS IN THE OFFSPRING OF THE VARIOUS TYPES OF MATINGS TOTAL FOR 3,643 PARENTS AND CHILDREN: TASTERS, 70.2%; NON-TASTERS, 29.8%.

Matings		Children	
		Tasters	Non-tasters
Taste × Taste 425		929	130
	obs.	0.877 ± .007	0.123 ± .007
	calc	0.876 ± .001	0.124 ± .001
	dev.	0.001 ± .007	0.001 ± .007
Taste × Taste deficient 289		483	278
	obs.	0.634 ± .012	0.366 ± .012
	calc.	0.646 ± .002	0.354 ± .002
	dev.	0.012 ± .012	0.012 ± .012
Taste deficient × Taste deficient 86		5	218
	obs.	0.021	0.979
	calc.	0.000	1.000
	dev.	0.021	0.021

Where both parents taste, the ratio of tasters to non-tasters in the offspring is about 7:1. This of course varies from the familiar 3:1 because a certain proportion of the tasting parents will be homozygous, producing all tasting children. The expected ratio of tasters and non-tasters among the offspring can only be calculated by first determining the frequencies of the allelomorphic factors in the general population. The same applies to families in which only one parent tastes, in which the familiar back-cross ratio of 1:1 will be changed due to the fact that some of the tasters will be homozygous.

The determination of the frequencies of the genes, the expected proportions of tasting and non-tasting children in various matings, and the consequent proof of the unit-character nature of the deficiency are given below.

Let us assume the taste deficiency to be a simple recessive character, designating the two allelomorphs as T and t, respectively.

Let p = frequency of T
and q = frequency of t.
Then $p + q = 1$. It is readily seen that

$$p^2 + 2\,pq = \text{tasters (A)}$$
$$q^2 = \text{non-tasters (B)}$$
$$q = \sqrt{B}$$
$$p = 1 - \sqrt{B}$$

In this case $p = .445$, $q = .545$

Since p^2 = homozygous tasters
and $2pq$ = heterozygous tasters,

$$\frac{p^2}{p^2 + 2\,pq} = \text{proportion of tasters which are homozygous}$$
$$\frac{2\,pq}{p^2 + 2\,pq} = \text{proportion of tasters which are heterozygous.}$$

From this it is easy to calculate the relative frequencies of matings of homozygous with homozygous, homozygous with heterozygous, and heterozygous with heterozygous, and consequently the proportion of recessive, non-tasting children to be expected from such matings. Since the only recessive children so produced will be one quarter of the offspring of heterozygous with heterozygous, a formula for this is readily derived. Similarly the calculation can be made for matings of tasters with non-tasters, where the recessive children will be one half of the offspring of matings of heterozygous with recessive. These formulae may be derived as follows:

Let R = proportion of recessive offspring to be expected from matings of dominant with dominant, and

S = proportion of recessive offspring to be expected from matings of dominant with recessive.

$$\text{Then } R = 1/4\left(\frac{2\,pq}{p^2 + 2\,pq}\right)^2 = \left(\frac{q}{p + 2\,q}\right)^2$$

$$\text{and } S = 1/2\left(\frac{2\,pq}{p^2 + 2\,pq}\right) = \frac{q}{p + 2\,q}$$

Since the frequencies p and q will vary for different samplings, the figures obtained from these formulae will of course vary, not only for other mutations occurring with different frequencies, but even for the same mutation in different races or populations. The frequencies of the allelomorphs must therefore be determined anew for each mutation of each new race.

By referring to Table I it can be seen that the deviations of the observed proportions from the expected proportions are well within their probable errors. The unit-character nature of the taste deficiency is thus amply proven.

The inheritance of taste deficiencies for still other compounds has been investigated in our laboratory and the results of these studies will soon be in press.

The probable errors of the observed and calculated proportions as given in Table I were obtained as follows:

$$\text{For the observed values, P. E.} = .6745 \sqrt{\frac{ab}{N}}$$

Where a = observed proportion of tasting children, b = observed proportion of non-tasting children, and N = number of offspring, for each type of mating.

For the calculated values, the probable error must be specifically derived. The complete derivation of these formulae is being given in a paper on the epistatic relationships of two types of taste deficiency, which we are now preparing for publication in "Genetics." For the present merely the resultant formulae are given. These are as follows:

$$\text{P. E.} \left(\frac{q}{p+2q}\right)^2 = \frac{.6745\ (1-\sqrt{b})}{4\ N\ (1+\sqrt{b})^2} \sqrt{\frac{16\ Nb}{1-b} - 1 - \frac{(1-2\sqrt{b})^2}{(1+\sqrt{b})^2} + \frac{2\ (1-2\sqrt{b})}{1+\sqrt{b}}}$$

$$\text{P. E.} \frac{q}{p+2q} = \frac{.6745}{8N\ (1+\sqrt{b})} \sqrt{\frac{16N\ (1-\sqrt{b})}{1+\sqrt{b}} - \frac{(1-\sqrt{b})^2}{b} + \frac{4\ (1-\sqrt{b})^2}{(1+\sqrt{b})\sqrt{b}} - \frac{4\ (1-\sqrt{b})^2}{(1+\sqrt{b})^2}}$$

Where b = the true value of the proportion of non-tasters in the population, which in practise must be taken as B, the observed value from the complete sample of individuals tested. N = total number of individuals tested.

A word may be added as to the inheritance of taste deficiency to di-ortho-tolyl-thio-carbamide, another compound investi-

gated. Approximately 35% of the individuals tested could taste both compounds, an equal number tasted only phenyl-thio-carbamide, and about 30% could not taste either compound. Moreover, in many families where neither parent tasted the second compound, some of the offspring did. This indicates an epistatic relationship of the two factors concerned. The analysis of this phenomenon, as well as the derivation of all formulae concerned, will be given in the previously mentioned forthcoming publication.

BIBLIOGRAPHY.

Blakeslee, A. F. and Salmon, M. R. Eugenical News, 16: 105, 1931.
Fox, A. L. Science 73, suppl.: 14, 1931.
Snyder, L. H. Science 74: 151, 1931.

An Introduction to Physical Science.

The title of this book, "Introduction to Physical Science," suggests that it might give a unified approach to the study of both physics and chemistry. Such, however, is not the case unless one concedes that physics is to be regarded as prerequisite to the study of chemistry and in that sense becomes an introduction to the study of chemistry. The intent of the book, however, is to introduce the student to the methods of scientific thinking as found in classical and modern physics and to acquaint him with some of the results of modern research in physics. The author recognizes in the preface the difficulty of compressing into such a limited space the necessary fundamental training for an appreciation of the developments which have characterized the last quarter of a century of physics and he is in my opinion correct in supposing that an introductory course in physics must include a survey of these newer developments as well as a consideration of the principles of classical physics.

In the selection and arrangement of the subject matter the author has been quite independent of the traditional order of presentation as found in most text-books of physics and has undertaken to present the essential principles of mechanics, heat, sound, light and classical electricity in sufficient detail to make it possible to understand selected topics from modern physics. Such topics as cathode rays, x-rays and positive rays, radioactivity, electric oscillations, relativity and wave mechanics are considered in somewhat greater detail than in most college text-books of physics. There is also an interesting chapter on cosmic physics. The chapter on wave mechanics and also the chapter on relativity seem to me to be too difficult for the type of student for whom the book was intended. The book seems clearly written, but many students and instructors will miss those more concrete illustrations and applications of physical principles which tend to make physical reasoning intimate and vital.

This book should serve as an excellent introduction to more advanced work in physics.—ALPHEUS W. SMITH.

Introduction to Physical Science, by Carl W. Miller. New York, John Wiley and Sons, Inc., 1932. $3.00.

BRYOZOA FROM CHESAPEAKE BAY.*

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The Bryozoa of Chesapeake Bay are interesting for several reasons: first, because of the unusual nature of the bryozoan fauna; second, the region is zoogeographically intermediate between the colder water fauna of New England and the subtropical fauna of Florida, and, third, there is almost no mention of this group between Southern New England and Florida in the literature.

The number of species taken by the Survey, nineteen, is much smaller than would have been expected from the area covered, and there is little doubt that a much larger number could be taken by careful collecting about the mouth of the bay. The purpose of the Survey was not to produce an extended list but to report the presence of the species occurring in certain areas. A large amount of material from more than 40 stations within the bay was carefully worked over. The stations extended from the mouth of the bay nearly to the city of Baltimore, but at the uppermost stations no Bryozoa were taken and most of the species were limited in distribution to the lower third of the region surveyed. Certain species of Ctenostomata were the only ones that could be considered abundant. One species of this group (*Victorella pavida*) is recorded for the first time in American waters, and another (*Amathia alternata*) has not been reported since Lamouroux reported it in 1824.

The bottom of the bay appears to consist almost entirely of mud, mixed in places with sand and shells. Apparently enormous masses of hydroid stems are drifted over the bottom. The writer assumed the task of separating the Bryozoa from the Hydrozoa and was continually astonished at the amount of dead hydroid material. It appears that most of this material must have been brought in by tides and currents from somewhere near the mouth of the bay, for these hydroids also do not flourish where the salt content is too low. Over a

*A report on the species of the off-shore waters collected by the Biological Survey of Chesapeake Bay, under the direction of Dr. R. P. Cowles. Published by permission of the United States Commission of Fisheries.

large part of the bay where Bryozoa may grow, these stems seem to be the only means of attachment for the various species recorded.

The water is made more or less brackish by the inflow from an unusual number of larger rivers; the Susquehanna, Patapsco, Patuxent, Potomac, Rappahannock, York and James, besides numerous smaller streams. No doubt this has an important bearing on the distribution of the Bryozoa, few of which are able to live in water that is less than two thirds of the salinity of pure sea water. According to records for 1920, 1921 and 1922, the salinity varies from about .7% near Baltimore to about 3.2% at the mouth of the bay. Only the bottom records are considered as the Bryozoa are all attached species. The salinity of the open ocean averages about 3.5 % of salts, and about 2.0% seems to be the lower limit of salinity for most of the bryozoan species.

The whole region within the bay is very shallow, 45.75 meters being the greatest depth, near the mouth of the bay, while most of the stations show less than one-third of this depth. Such a body of water influenced by a large inflow from the rivers, necessarily fluctuates greatly in temperature, even at the bottom, and this also no doubt affects the distribution of the species.

ENDOPROCTA

Barentsia discreta (Busk).

Sta. 8903, not far from the mouth of the bay, at 47.75 meters. One small colony attached to a stalk of *Amathia alternata*. A widely distributed species, but recorded rather infrequently. On the North American coast the writer has taken it at Woods Hole, Massachusetts; Beaufort, North Carolina, and the Tortugas Islands, Florida.

ECTOPROCTA

Cyclostomata

Crisia eburnea (Linnaeus).

Sta. 8850, 8938 and 8940, all in the lower third of the bay. The species is cosmopolitan in distribution.

Cheilostomata

Bugula turrita (Desor). (Plate I, Fig. 1.)

Sta. 8827, mouth of bay, 18.3 meters, two small colonies attached to shell fragments. This abundant species of the southern New England region appears to be much less common south of New Jersey, though the writer has taken it as far south as Beaufort, North Carolina.

Bugula gracilis var. *uncinata* Hincks

Sta. 8893, not far from the mouth of the bay, at 44.83 meters. The species is known from Woods Hole and Lynn, Massachusetts, from England and Madeira. Where found it does not seem to be a common species, but probably its optimum habitat has not been located.

Nitscheina (*Membranipora*) *membranacea* (Linnaeus).*

Sta. 8949, at 7.78 meters, about half way up the bay, one colony on algae. It was also taken at another station the number of which was obliterated, but the date indicates that the location is somewhere off the city of Annapolis. This is the farthest up the bay that any bryozoan species was taken. *N. membranacea* is well known for its tolerance of brackish water conditions in various regions of the world.

Electra (*Membranipora*) *pilosa* (Linnaeus).

Sta. 8838, mouth of bay, 16.4 meters, one colony on a shell fragment. A very widely distributed species.

Electra (*Membranipora*) *monostachys* (Busk).

Sta. 8838, at mouth of bay, 16.4 meters, on shell fragments. Widely distributed in the North Atlantic.

Hemiseptella (*Membranipora*) *denticulata* (Busk).

Occurring at nine stations well distributed over the lower part of the bay and north to the mouth of the Potomac River. The lowest salinity where it occurred was about 1.5%. One colony was bilaminate and spread from branch to branch of a hydroid. A common species from Cape Cod southward to Florida and found also on the west coast of Mexico.

Hippothoa hyalina (Linnaeus).

Sta. 8827, mouth of bay, 18.3 meters. A very widely distributed species.

Schizopodrella unicornis (Johnston).

Sta. 8173, near mouth of bay, 12.8 meters. Also a common species occurring over a very wide range.

Microporella ciliata (Pallas).

Sta. 8173, mouth of bay, 18.3 meters Cosmopolitan in range.

Ctenostomata

Alcyonidium polyoum (Hassall), (*A. mytili* Dalyell).

Sta. 8827, near mouth of bay, one colony on a shell. Widely distributed.

Alcyonidium verrilli Osburn. (Plate I, Figs. 2 and 3.)

Taken at 22 stations ranging all over the lower part of the bay

*For references and synonymy see Osburn, Bryozoa of the Woods Hole Region, Bul. U. S. Bureau of Fisheries, Vol. XXX, No. 760, 1912. The generic names in parenthesis are those used in that report.

up to above the mouth of the Potomac River, at depths ranging from 7.3 to 45.75 meters. The lowest salinity observed was at the mouth of the Potomac River, 1.319%. This species was the most abundant and widely distributed of all the Bryozoa taken by the Survey. Numerous young colonies incrusted hydroid stems, and larger colonies, branching freely, rose to height of 100 to 125 mm., with branches 3 to 5 mm. in diameter. The colony appears to begin as a thin layer, which later rises into the erect branching form. In consistency this species is much firmer than *A. gelatinosum* and *A. hirsutum*, both of which grow in somewhat the same branching form.

Hitherto the species has been recorded only from southern New England and New Jersey.

Alcyonidium parasiticum (Fleming).

Sta. 8838, mouth of bay, 16.4 meters, encrusting hydroid stems.

Anguinella palmata Van Beneden.

Taken at eight stations, all well within the bay in the general region of the mouth of the Potomac River, the salinity ranging from about 1.3 to 2.1%. This distribution appears to be characteristic since at Beaufort, North Carolina, where the species is abundant, it thrives especially on the piles of docks well within the harbor, and at Buzzard's Bay, which appears to be its northern limit, it occurs in a similar situation.

Bowerbankia gracilis Leidy.

Noted at five stations ranging from near the mouth of the bay to about three-fifths of the way toward the head, the salinity varying from 1.5 to 2.4%. All of the colonies were spreading over hydroid stems, sometimes covering them as with a dense fur. Most of the specimens were of the variety *caudata* of Hincks.

Amathia alternata Lamouroux. (Plate I, Fig. 4.)

1816, Hist. Pol. Cor. Flex., p. 160.
1821. Exp. Method, p. 10, Pl. LXV, Figs. 18–19.
1824, Encycl. Method, p. 44.

Recorded from seven stations all in the lower fifth of the bay, at depths ranging from 12.8 to 45.75 meters. The species is not so abundant, nor does it reach so large a size as it does farther south, though the largest colonies attained a height of 75 mm. It has not been recorded for the coastal waters of North America, although the writer has found it to be very abundant at Beaufort, North Carolina, where it is thrown up on the outer beaches in great numbers. The erect, tree-like, light brownish colonies, with their spirally arranged zooecia and tough stems, are like nothing else in our fauna. The larger stems measure about .5 mm. in diameter, the retracted zooecia average about .6 mm. in length by about .135 mm. in width and in each group they are graduated somewhat in length from the lower zooecia upward. The spirals may alternate in direction, turning either to right or left in the same colony.

It appears unusual that so large and striking a species should not have been recorded by anyone for more than a century and remain known only from the type material, but the species of Amathia are not very well known and it is possible that it has been recorded under another name. Lamouroux, in his first description named Deshayes as the collector and the locality as "mer d'Amerique," but in his revised statement in 1824 he gives the locality as "mer des Antilles," with the same collector. The probability therefore is that Deshayes found the species somewhere about the West Indies.

I am indebted to Dr. Sidney F. Harmer, the eminent English authority on the Bryozoa, for his opinion, confirming my own, that this species is the *alternata* of Lamouroux.

Victorella pavida Saville Kent. (Plate I, Fig. 5.)

Kent, Quart. Jour. Micr. Sci., n. s., Vol. X, p 34, Pl. IV.
Hincks, British Marine Polyzoa, p. 561, Pl. LXXIX, Figs. 4–7.
Kraepelin, Abhand. Verein Hamburg, Vol. X, Taf. III, Fig. 75.

Taken at four stations, 8874, 8883, 8891, and 8893. The distribution ranges from near the mouth of the bay to well above the mouth of the Potomac River, with the salinity varying from 1.7 to 2.7%. This species was a surprise in the collection as it had not been previously recorded from American waters, though it is known from England, Germany and Australia. It is supposed to occur only in waters of slight salinity, "amongst a prevailing fluviatile fauna," (Hincks).

The zooecia look like those of a very delicate *Bowerbankia* in general appearance, though the type of budding is quite different (Fig. 5), there is no gizzard and there are only 8 tentacles. Knowing the variability in appearance of many ctenostomes in different states of preservation, I was somewhat doubtful of my determination of the species as *V. pavida*, and submitted specimens to Messrs. S. F. Harmer and R. Kirkpatrick of the British Museum for comparison. Kirkpatrick writes as follows: "Your example differs a good deal from the typical material, but on the other hand resembles closely the figures of Kraepelin. We are both inclined to think you would not be far wrong if you named your specimen *Victorella pavida*." So the determination stands at present and must remain until better preserved material can be properly studied.

Triticella (Hippuraria) elongata (Osburn).

In the gill chamber and spreading slightly on the outside of the shell of a blue crab (*Callinectes sapidus*) from Fish Hawk Sta. 8498,

Chesapeake Bay. No crabs were sent me by the Survey, but one of two specimens received from the U. S. National Museum bore this species, which seems always to be associated with crabs, especially spreading over the walls of the gill chamber. *T. elongata* is probably common enough on various species of the Chesapeake crabs, as the writer has taken it at Woods Hole, Massachusetts, and more abundantly at Beaufort, North Carolina, on the blue crab, the spider crabs (*Libinia* spp.) and on the species of *Pinnixia* which inhabit the tubes of the worm, *Chaetopterus*.

It is worthy of note that in the preceding list nearly all of the species have a very wide distribution. Only four, *Bugula turrita*, *Alcyonidium verrilli*, *Amathia alternata* and *Triticella elongata*, are limited, as far as our present knowledge goes, to the Atlantic Coast of North America.

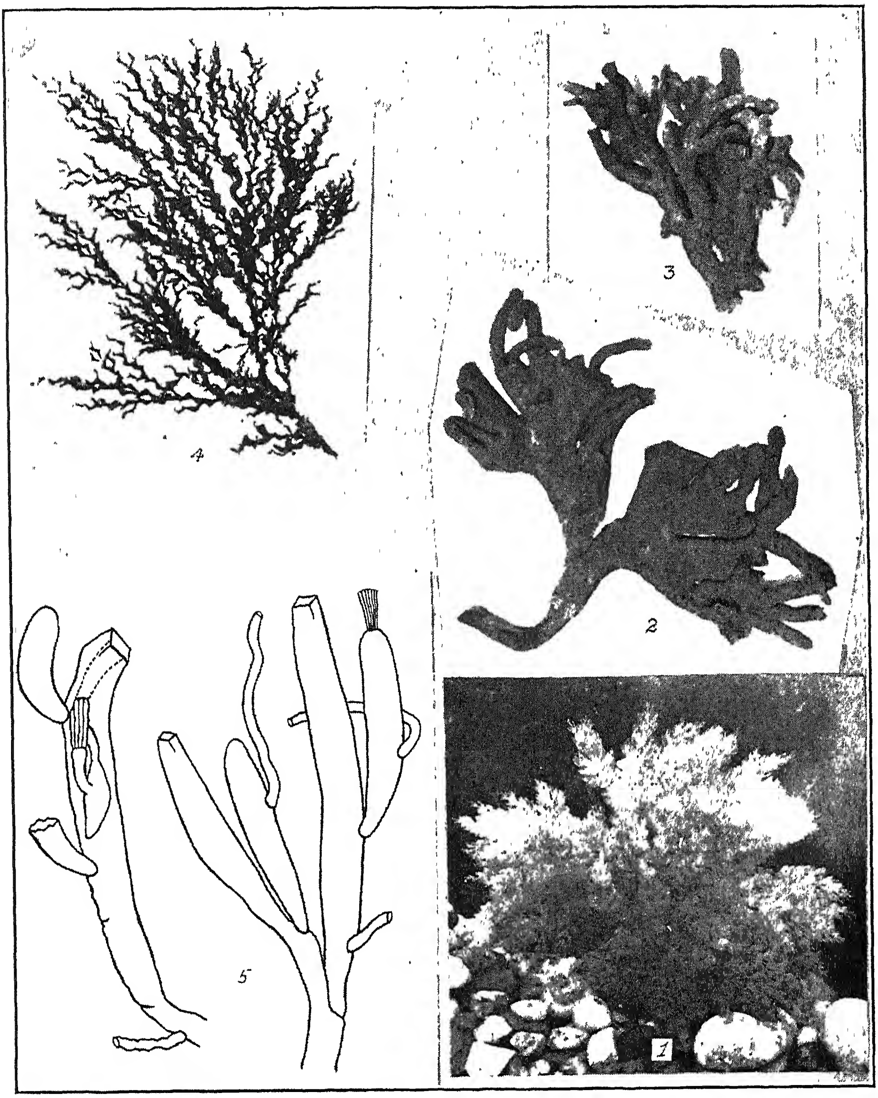
EXPLANATION OF PLATE.

Fig. 1. *Bugula turrita* (Desor), a well developed specimen from Long Island Sound. Natural size.

Figs. 2 and 3. *Alcyonidium verrilli* Osburn, showing differences in form of colony. About one-half natural size.

Fig. 4. *Amathia alternata* Lamouroux, a typical colony but spread out somewhat for photographing. The opposite direction of the spirals may be observed on some branches. Natural size.

Fig. 5. *Victorella pavida* Kent, diagrammatic drawings showing mode of branching and other details.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THE NEWARK DRAINAGE SYSTEM IN KNOX, LICKING, AND NORTHERN FAIRFIELD COUNTIES.

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INTRODUCTION.

The Newark Valley was first named and described in a paper written by G. W. Tight and published about 1897 in Vol. VIII of the Bulletin of Denison University. The general features of this valley were noted and the probable outlet to the southwest was discussed by Leverett in 1902.[1] Since that time papers by various authors have appeared from time to time in the Bulletin of Denison University dealing with local changes of drainage in the vicinity of Granville, Newark, and Hanover, but little concerted effort has been made to add to the data on the Newark Valley or to map out and record the drainage of Newark age in the region lying north of Newark in Licking and Knox counties.

In his report on Knox and Licking counties, Read mentions some old filled channels in the vicinity of Mt. Vernon and Martinsburg.[2] In his early work Tight states that "the preglacial channel of North Fork probably extended into Knox County and received the head waters of Owl Creek,"[3] but later as reported and approved by Leverett he considered that a divide crossed the North Fork near Utica and that the waters north of this divide discharged into the Scioto basin through an old channel extending westward past Homer.[4] In a later paper Scheffel concludes that the drainage of the lower portions of the valleys of Raccoon Creek, Brushy Fork, and North Fork drained into the Newark Valley.[5] Much data is now available in the form of well records which did not exist at the time of the early investigations but which adds

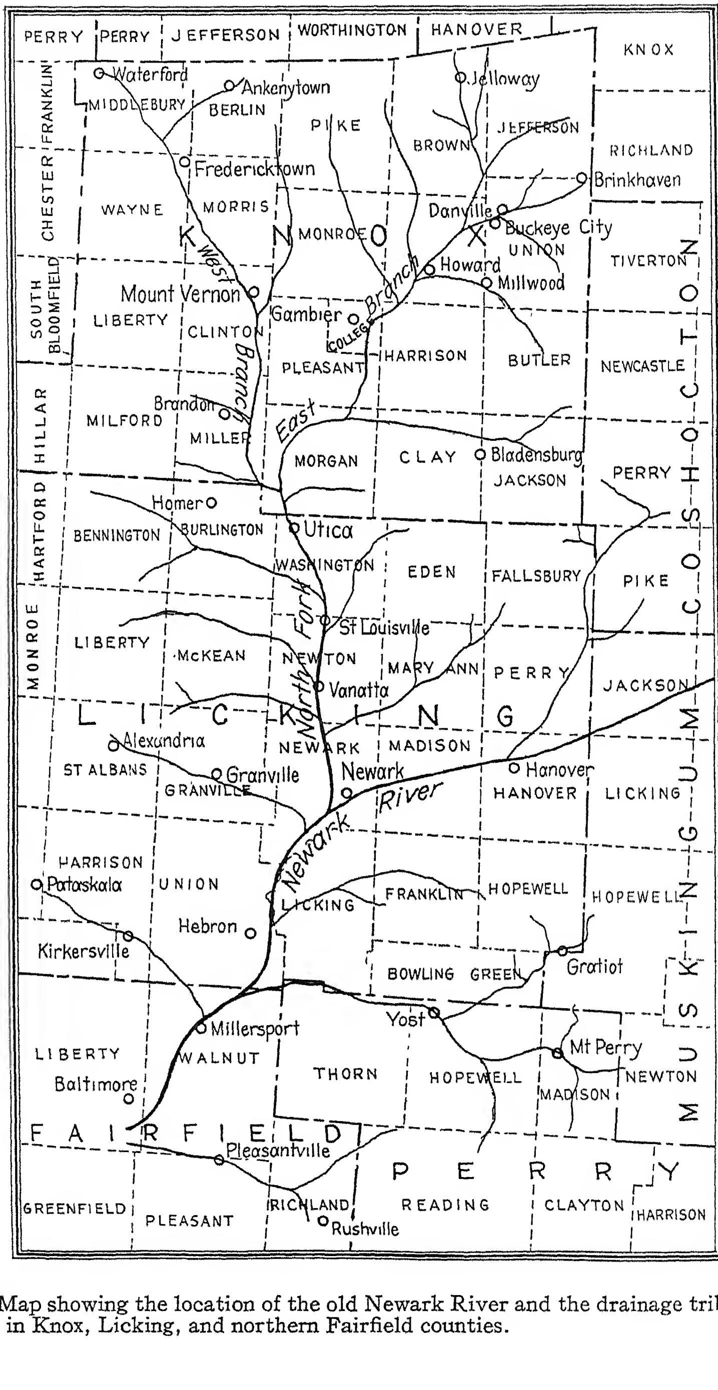
[1]Leverett, Frank, U. S. Geol. Survey, Mon. XLI (1902), p. 155.

[2]Read, M. C., Geol. Survey Ohio, Vol. III (1878), pp. 325–361.

[3]Tight, W. G., A Contribution to the Knowledge of the Preglacial Drainage of Ohio. Bull. Denison University, Vol. VIII (1897), p. 37.

[4]Leverett, Frank, U. S. Geological Survey, Mon. XLI (1902), pp. 160–161.

[5]Scheffel, E. R., Drainage Changes Near Granville, Ohio. Bull. Denison University, Vol. XIV (1908), pp. 171–172.



Map showing the location of the old Newark River and the drainage tributary to it in Knox, Licking, and northern Fairfield counties.

much to our detailed knowledge not only of the Newark Valley but of the Newark drainage system throughout eastern Licking and Knox counties. To record such data and to state the conclusions derived from its study is the purpose of this paper.

During the past thirty years many deep wells have been drilled to the Clinton sand over a broad belt extending from Lancaster, Fairfield County, northward past Newark and Granville to Mt. Vernon and also along the old valley from Newark east to Frazeysburg. The records of several hundred wells located in these areas have been secured, their locations carefully plotted on maps, and the lengths of the drive pipe noted. Where such locations occur along streams or on flat lands the well-head and bed rock elevations have been determined within narrow limits of error. Where rock gorges occur partially or completely filled with glacial drift, it is necessary in figuring valley profiles to assume that the lowest bed rock elevation in any locality represents the old valley bottom. The chief drainage lines of the old Newark system in Licking and Knox counties which have been determined in this way are shown on the accompanying map.

THE NEWARK VALLEY.

The Newark Valley extends from Trinway past Frazeysburg and Hanover to Newark where its course turns more to the southwest. East of Newark the valley is a distinct topographic feature but southwest of that town it is so choked with glacial drift that beyond Buckeye Lake its position can not be determined by surface contour. Its course, however, can be traced by well records as far as Baltimore, Liberty Township, Fairfield County. Beyond Baltimore very few wells have been drilled and therefore little data can be secured. However, the most likely course for the old channel is westward past Canal Winchester where in all probability it turns to the southwest meeting the axis of the Scioto basin a short distance north of Circleville.

Between Newark and Frazeysburg the old valley is rock bound for outcrops are present along its slopes high above present bottom flats. The filling varies in thickness from 314 feet at Newark to about 165 feet near Trinway. Many wells drilled near Black Run in the northwestern part of Jackson Township, Muskingum County, record alluvium in this valley of 200 feet or more in thickness. At the C. B. Fawcett well

located near the center of the valley about 2 miles west of Trinway, bed rock was struck at a depth of 166 feet, giving an elevation for the rock floor at this place of about 600 feet above tide. At the Amos Zartman well just south of the fairgrounds at Newark and also situated near the center of this old valley, bed rock with an elevation of 537 feet was reached at a depth of 297 feet below the surface. The distance between these two wells is about 22 miles making an average slope of the valley floor to the southwest of about 34 inches per mile.

From the west edge of Newark the old channel is directed a little west of south passing a short distance east of Hebron to the north shore of Buckeye Lake. Here the valley turns to the west and extends beneath the western end of the lake as far as Millersport where it again turns to the south and passes about a mile northwest of Thurston to a point approximately one mile south of Baltimore. The maximum thickness of the drift in this part of the valley is about 350 feet. In the region lying immediately north of Buckeye Lake wells penetrate drift ranging from 65 to 345 feet in depth. The lowest point of which we have record in the old channel in this vicinity was reached in the Cliff Sturgeon No. 3 well located on the north shore of the lake about one mile southwest of the electric railway terminal. The drift here has a thickness of 344 feet and the elevation of bed rock is about 540 feet.

Southwest of the west end of Buckeye Lake glacial drift in excess of 300 feet in thickness is of common occurrence. At the Marie Fry No. 1 well in the south part of Section 27, Walnut Township, the drift measures 316 feet, while the elevation of bed rock is about 585 feet. The record of the Thomas Bryson No. 1 well in Section 4, Walnut Township, shows 388 feet of drift with bed rock at a height of 550 feet. Deep wells drilled at Thurston and Baltimore penetrate drift exceeding 300 feet in thickness,and reach bed rock at elevations of approximately 550 feet. Records now available indicate that the lowest elevation of bed rock in the old valley occurs in the northwestern part of Section 30, Liberty Township, where in the Adam Wagner No. 1 well the drift has a thickness of 339 feet and the rock floor has a height of about 521 feet above sea level which is about 17 feet lower than at the Zartman well at Newark. The distance between these two wells measured along the channel defined by well records is

about 17.7 miles. The average fall to the southwest is therefore about 10.8 inches per mile for that part of the valley between Newark and Baltimore. If this gradient were projected along the most probable course past Canal Winchester in the direction of Ashville, the elevation of the channel at the latter place would be about 500 feet. That thick deposits of drift occur near Ashville is evidenced by the record of the L. C. O'Daffer well drilled about one mile northwest of town where bed rock having an elevation of 535 feet was reached at a depth of about 167 feet.

VALLEYS TRIBUTARY TO THE NEWARK CHANNEL.

Southwest of Newark the upper surface of bed rock rises rather abruptly along the east side of the old Newark channel for it reaches heights of 150 to 200 feet in the horizontal distance of a mile. The regularity of the slope is broken at a few places by tributary channels which received waters from the region lying to the eastward. One of the largest of these tributaries had its head waters in the northwestern corner of Reading Township, Perry County. It extended to the southwest across northern Richland Township to a point a little south of Shakes Run School where it turned to the northwest, passed through Pleasantville, and united with the Newark Valley south of Baltimore. It was joined from the south by a tributary valley which headed a short distance southwest of Rushville, flowed northwest, and met the main tributary in the northwestern corner of Section 20, Richland Township. The position of these tributary valleys is marked by an excessive thickness of drift. In the central part of Section 10, Richland Township, the drift has a thickness of 195 feet. Wells drilled near Shakes Run School show 240 and 273 feet of drift while at Pleasantville the drift reaches a thickness of 322 feet.

A second and larger tributary entered the Newark channel at Buckeye Lake. Its head waters received much of the drainage of Madison and eastern Hopewell townships, Muskingum County, and of southern Hopewell Township, Licking County. The course of this channel is located along the site of the present valley of Jonathan Creek as far as the Perry-Muskingum County line where a col formerly existed.[6] Secondary tributaries extended along the sites of what are now

[6]Davis, H. J., Modifications in the Jonathan Creek Drainage Basin. Bull. Denison University, Vol. XI (1899), pp. 164–175.

Painters Run, Turkey Run, and Valley Run in Madison and Hopewell townships. Little data on the thickness of the drift can be secured in this region. However, well No. 1 situated on the Fred S. Mechling property at Yost in Section 5, Hopewell Township, Perry County, and located near the center of the old channel, penetrated 207 feet of drift before reaching bed rock. At the John Yost No. 1 well near Thornville Station the thickness of the drift is about 290 feet and the elevation of bed rock is about 615 feet above tide. The course of the old valley apparently paralleled the southern shore of the eastern half of Buckeye Lake, meeting the Newark channel near the western end of the lake.

A third valley of less extent is followed closely by the present valleys of Swamp Run and Claylick Creek from eastern Franklin Township, Licking County, as far west as Fleatown where the valley took a southwestern direction joining the axial channel a short distance east of Hebron. Northeast of Fleatown bed rock occurs above the level of the present drainage which in a part of its course flows on a thick deposit of glacial drift. About 112 feet of such material was penetrated before reaching bed rock at the Sina Swisher No. 1 well located about 2 miles above Fleatown, and 187 feet was recorded at the Davis No. 1 well located one-half mile west of Fleatown.

Valleys from the west tributary to that part of the Newark channel located southwest of Newark are not clearly defined as the glacial drift deposits are generally thick and as few deep wells have been drilled. The upper surface of bed rock apparently rises to the northwest from Baltimore, for in the northwestern quarter of Section 12, Liberty Township, only 54 feet of drift were recorded in well No. 1 on the F. P. Miller farm. As the well-head elevation is about 950 feet, the upper surface of bed rock occurs here at an elevation of about 896 feet or some 370 feet above the level of the Newark channel to the east. A large tributary apparently headed in the direction of Pataskala, flowed southeast past Kirkersville, and entered the axial channel near the western end of Buckeye Lake. A deep well drilled along this old channel about 2 miles northeast of Etna and near the southern edge of Harrison Township penetrated 320 feet of drift and struck bed rock at an elevation of about 645 feet. A second deep well located about 1¼ miles east of Etna reached rock at a depth of 183 feet or at an elevation of about 850 feet. The drift is generally

thick in the northwestern part of Union Township, for wells show depths ranging from 230 to 350 feet. Bed rock elevations in this part of the township vary from 620 to 665 feet. The rock surface rises to the north, however, for it reaches heighths of 800 feet or more in the northwestern part of Union Township.

RACCOON VALLEY.

During the Newark stage a deep channel was cut along the site of the present valley of Raccoon Creek at least as far west as Alexandria.[7] The depth of the valley filling is about 220 feet below stream level at Alexandria and about 250 feet at Granville. West of Alexandria the old channel is not clearly defined as well data is lacking. South of Raccoon Creek rock outcrops occur along Moots Run in St. Albans Township, and the upper surface of bed rock extends to or above the level of Raccoon Creek in southwestern Granville Township. Wells drilled along the north slope of the valley penetrated drift ranging in thickness from 45 to 160 feet. At the Andrew Board No. 1 well located one mile northeast of Alexandria bed rock having an elevation of about 1000 feet was reached at a depth of about 40 feet. Bed rock with an elevation of about 960 feet was encountered at a depth of about 160 feet at the Tally No. 1 well situated along the road three-fourths of a mile southeast of St. Albans Church. A third well drilled on the Chas. Guckert property two miles northeast of Granville showed 46 feet of drift with bed rock encountered at an elevation of about 1030 feet. A fourth well on the William Howe farm north of Granville penetrated 63 feet of drift before reaching solid rock which has an elevation at this place of about 970 feet.

NORTH FORK AND ITS TRIBUTARY VALLEYS.

The axial drainage of the Newark system was joined at Newark by a large tributary from the north which had its head waters in northern Knox County. The main channel of this tributary followed closely the site of the present North Fork of the Licking River from the southwestern corner of Morgan Township, Knox County, to its mouth at Newark. For purposes of convenience in this description it will be known as

[7]Scheffel, E. R., Significance of Drainage Changes Near Granville, Ohio. Bull. Denison University, Vol. XIV (1908), pp. 157-174.

the North Fork of the Newark Valley. In Morgan Township the North Fork was formed by the union of two branches, an East Branch which had its head waters in Pike, Brown, and Jefferson townships, Knox County, and a West Branch which headed in Berlin and Middlebury townships and probably received waters from the east-central part of Morrow County.

The North Fork of the Licking River from Morgan Township to its mouth flows on glacial material which varies from 300 to 360 feet in thickness. This excessive thickness of drift represents the amount of filling in the old channel which was much narrower than the present valley. Wells drilled near the margins of the valley flats sometimes show comparatively little drift, while wells more centrally located reach bed rock at much greater depths. Bed rock in the Newark channel near the mouth of North Fork lies some 300 feet below the surface and has an elevation of about 537 feet. At the Frank A. Dusk No. 1 well located west of the center of the valley in southern Newton Township bed rock with an elevation of about 680 feet was reached at a depth of 231 feet. The record of the McKinney well situated near the eastern edge of the valley three-eighths of a mile southeast of Vanatta, shows that 110 feet of drift was penetrated before reaching bed rock which occurs at this place at an elevation of about 730 feet. A third well drilled near the center of the old channel 1½ miles south of St. Louisville reached rock at a depth of 276 feet. The elevation of the upper surface of solid rock at this well is about 605 feet or about 68 feet above the level of the channel at Newark. The record of another well located on the William Weitham farm, a half of a mile east of the mouth of Lake Fork, shows 336 feet of drift with bed rock at a height of 614 feet. At the junction of East Branch and West Branch the upper surface of bed rock occurs at an elevation of about 655 feet, which is 118 feet higher than the level of the old channel at Newark. Based on these figures the average slope of the old channel of North Fork was slightly more than 7 feet per mile to the south.

Leverett examined the valley of North Fork and found low rock hills in the midst of lowlands about 3 miles south of Utica. He concluded therefore, that a divide formerly existed at this place which barred a southward course for the drainage of the region lying to the north. In accordance with Tight's opinion Leverett concluded that the discharge was westward

to the Scioto basin past Homer.[8] The data derived from well logs is not in accordance with Leverett's interpretation. Wells drilled on the present valley flats about 2½ miles south of Utica and therefore a little north of the proposed divide, show the presence of a deep channel as much as 336 feet below the general level of the lowlands. Here the elevation of bed rock, which is about 614 feet, is only about 60 feet higher than it is at Newark and it is lower than at any place in the old channel farther north. These facts point to a southern direction of discharge past Utica to Newark.

West of North Fork many well records in Bennington, Burlington, McKean, Liberty, Granville, and St. Albans townships show that bed rock occurs on the uplands at elevations ranging from 950 to 1150 feet, while east of the valley in Newark, Newton, Washington, and Morgan townships the upper surface of bed rock rises to elevations ranging from 750 to 1050 feet.

Three tributaries of some size entered the North Fork from the east. The first and most northern one of the three had its head waters in southeastern Morgan Township and flowed in a westerly direction past White Oak School. A well drilled along this channel on the Rachel Bell farm one-half mile west of White Oak School struck bed rock at an elevation of about 790 feet after penetrating 212 feet of drift.

A second tributary channel entered the North Fork near St. Louisville. Its valley extended to the northeast through eastern Washington Township along a course now followed closely by a southwestern branch of Rocky Fork. A boring at the Redbrush School penetrated 335 feet of drift before reaching solid rock, while five-eighths of a mile farther west a well having about the same elevation reached rock at a depth of about 178 feet. At the M. J. McClelland No. 1 well located along this old channel about 1½ miles north of Redbrush School rock was reached at a depth of about 280 feet. As the casing-head elevation is about 1025 feet, bed rock at this well has an elevation of about 745 feet. One-half mile northeast of the McClelland well, a test on the M. H. Thrapp farm showed 245 feet of drift with bed rock at an elevation of about 765 feet. To the northwest and southeast of the McClelland and Thrapp wells borings show that bed rock rises to elevations

[8]Leverett, Frank, U. S. Geol. Survey, Mon. XLI (1902), p. 161.

of 1000 feet or more. From the Thrapp well the old channel extends into northwestern Eden Township.

The third tributary from the east entered North Fork in the northern part of Newark Township. It extended to the northeast past Newton Chapel, Wilkins Run, and Hickmon, and had its headwaters in northwestern Perry, southwestern Fallsbury, and eastern Eden townships. Rocky Fork now receives waters from much of the area which formerly drained through this tributary channel. Few wells have been drilled along the course of this old valley and no data on the thickness of the drift is at hand.

Many tributaries entered the North Fork of the Newark Valley from the west but only three are sufficiently well developed to merit much consideration. Two of these tributaries can be traced west to a line extending due north from Alexandria, St. Albans Township. West of this line their course is in doubt as no well data can be secured. Beginning at the north the first large tributary enters the channel of North Fork about one mile north of St. Louisville. This channel was formed about one mile west of Pattons Corners by the union of two tributaries, one from the northwest and the other from the southwest. Southeast of Pattons Corners the course of the old valley is parallel to Lake Fork but lies a little to the south of it. The drift along the course of this valley ranges in thickness from 250 to 400 feet and the elevation of bed rock varies from 615 feet at its mouth to 710 feet in central Bennington Township. On the divide areas to the north and south of this channel the drift rarely exceeds 150 feet in thickness with bed rock occurring at elevations ranging from 950 to 1100 feet. At the D. Myers No. 1 well located in the valley of North Branch about one mile south of the Licking School in Bennington Township, the upper surface of bed rock with an elevation of 715 feet, was reached at a depth of 395 feet. A well drilled along the South Branch about three-fourths of a mile southwest of Beech Knob School penetrated 381 feet of drift before reaching bed rock which at this place has an elevation of about 710 feet. In the region of Fairview School between these branches solid rock occurs at elevations exceeding 900 feet. A half of a mile southeast of Pattons Corners a well located along the main channel of this tributary penetrated 357 feet of drift striking bed rock at about 640 feet above sea level.

The second tributary from the west apparently extended from the central part of Liberty Township to the channel of North Fork near the present site of Vanatta. The Clear Fork of the Licking River follows very closely the course of this old valley. Well records show the elevation of bed rock near Hancock School to be about 920 feet or approximately 300 feet below the surface. Within one mile north or south of this location the upper surface of bed rock rises over 100 feet. One-fourth of a mile east of Brooks Corners a well penetrated 272 feet of drift reaching solid rock at an elevation of about 860 feet. Few wells have been drilled along the channel east of Highwater. However, a boring three-fourths of a mile southeast of Blackhawk School on the south side of the present valley passed through 140 feet of drift, reaching bed rock at an elevation of 860 feet. On the highlands to the north and south of the valley the drift is generally much thinner with bed rock occurring at elevations of 1050 to 1150 feet. A well along the south side of the valley in western Newton Township reached bed rock at an elevation of about 825 feet.

The third and smallest tributary from the west apparently headed in northwestern Granville and southwestern McKean townships and took a course to the North Fork along the site of the present valley of Brushy Fork. A well drilled on the Alva Hamilton farm near the headwaters of this tributary in northwestern Granville Township, showed 245 feet of drift overlying rock which stands at an elevation of about 775 feet. A mile east of this location and on the south side of the valley bed rock has an elevation of about 860 feet, while one mile southeast it rises to 1035 feet, and one mile west it has an elevation of about 960 feet. From the bed of this old channel the upper surface of bed rock rises to the north reaching elevations of 1000 to 1200 feet in McKean Township and 1000 feet or more in eastern Granville Township.

EAST BRANCH OF NORTH FORK AND ITS TRIBUTARIES.

From its junction with the West Branch near the mouth of Sycamore Run in Morgan Township, Knox County, the old channel of East Branch can be traced by well borings in a northeasterly direction to the headwaters of Big Run. Here the channel took a more northern direction to the Kokosing Valley along a course lying slightly west of the present valley of Big Run. From the mouth of Big Run the channel of

East Branch extended along the site of the Kokosing Valley to Howard where it continued in a northeasterly direction through the valleys of Jelloway Creek and Dowd Creek to the present Mohican Valley in eastern Jefferson Township. Excessive thicknesses of drift are recorded in the records of wells drilled along this channel. Near the junction of East Branch and West Branch in Morgan Township, the drift has a thickness of about 300 feet while the bed rock elevation is about 655 feet. Surface materials of similar thickness are found along the channel in Morgan and eastern Pleasant townships. The E. L. McMahon No. 1 well situated along Big Run in the northeastern corner of Pleasant Township is probably centrally located with respect to the old channel as it penetrated 228 feet of drift before reaching bed rock at an elevation of about 720 feet. The rock slopes rise abruptly from this old channel, for the upper surface of bed rock stands at elevations of 1000 feet or more in the northwestern corner and the north central part of Morgan Township and also over much of central and western Pleasant Township.

The channel of East Branch apparently extended along the site of the present valley of the Kokosing River from Howard to the mouth of Big Run. Little well data on the depth to bed rock is available in this part of the valley. That it is deeply filled with drift is indicated however, by the record of the Kidruff No. 1 well located at the northern edge of the valley and at the southern edge of Howard Township where bed rock was reached at a depth of 129 feet.

Along the course of Jelloway Creek and Dowd Creek northeast of Howard valley filling in excess of 100 feet in thickness is present, while on the bordering uplands the surficial deposits vary from 25 to 60 feet. At the James A. Greer No. 1 well located near the west edge of the valley in the northeastern corner of Howard Township, rock with an elevation of about 840 feet was encountered at a depth of 121 feet. At the Rila Rabjohn No. 2 well situated in the valley just north of Dowd Run in the southwestern corner of Section 8, Jefferson Township, rock was reached at a depth of 117 feet or at an elevation of about 900 feet. The deep channel is believed to continue northeast of the Rabjohn well past the Pleasant View School at least as far as the Mohican River, but well data along this part of its course is not at hand. The average slope of the valley of East Branch from the north edge of Howard Town-

ship to the north edge of Morgan Township is about 13½ feet per mile. From the latter point where a large tributary enters from the east to its junction with the West Branch, the valley slopes to the southwest at a rate slighlty in excess of 5 feet per mile.

Valleys tributary to the East Branch were numerous but data on the amount of filling is somewhat meager. The largest tributary entered East Branch from the east through northeastern Morgan Township and northern Clay Township. It received the waters of Harrods Run and had its head waters in the area now drained by Wakatomika Creek east of Bladensburg. A well drilled in this channel on the E. Rinehart property near the eastern edge of Morgan Township penetrated 318 feet of drift reaching bed rock at an elevation of about 680 feet.

A tributary entered East Branch from the northwest near the present mouth of Big Run. This tributary received the waters of Wolf Run and flowed in a southeasterly direction along the present course of the Kokosing valley to the channel of East Branch. A well drilled on the river bank just west of Kenyon College penetrated 40 feet of drift before reaching bed rock. Two miles west of Gambier the Kokosing River flows in a rock-bound channel.

A second tributary from the northwest had its head waters in central Pike Township and followed a course to the southeast along the valleys of Little Schenck Creek and Schenck Creek, joining East Branch in the southwestern part of Howard Township. No well data on the thickness of valley filling is at hand. A third tributary from the northwest followed the site of Little Jelloway Creek from eastern Pike Township, meeting the East Branch near the present mouth of Schenck Creek. The lower part of this tributary valley contains an excessive thickness of glacial material as shown by the record of the N. H. White No. 1 well located in the old channel one mile east of Fairview School where 184 feet of drift is found. A second well is located near the present stream level on the T. J. Porter farm, five-eighths of a mile south of the north boundary of Howard Township, passed through 83 feet of drift material before reaching bed rock. On the uplands both east and west of this location, well records show less than 60 feet of glacial material.

In the southeastern part of Brown Township the East Branch was joined by a tributary which headed along its

northern boundary and flowed southward along the site of Jelloway Creek, but in a channel much deeper than the present valley. It was joined by a tributary from the west which had its head waters near Cottage Hill School, and also by a tributary from the northeast which flowed along the site of Hadley Valley. Definite data on the thickness of the drift is likewise meager along the course of these tributary channels. Leveritt reports that flowing water wells 40 feet in depth have been secured in the drift in the valley at Jelloway.[9] Very little glacial drift is present on the uplands in this vicinity.

A drift filled channel extends from Brinkhaven southwest past Danville, meeting the present valley of Jelloway Creek in the eastern part of Howard Township. This channel was evidently a tributary to the East Branch of the North Fork of the Newark Valley. Leveritt cites a well drilled to a depth of 136 feet at Danville without striking bed rock.[10] As the major part of the town has an elevation ranging from 1,000 to 1,040 feet, bed rock at this place can not be much above 900 feet elevation and is probably somewhat below this level. Oil wells drilled about one mile northwest of Danville struck solid rock at or above elevations of 1,050 feet. The topography suggests that this deep channel was joined at Danville by two tributaries, one from the northeast and the other from the southeast. The first of these tributaries had its head waters near Turkey Ridge School in Jefferson Township and followed a course along the site of the East Branch of Jelloway Creek. A well drilled on the Louis A. Lower farm and located on this channel in the central part of Section 24, reached rock at a depth of 82 feet, while on the hills to the northwest and southeast bed rock lies close to the surface. The second tributary apparently headed in the direction of Flat Ridge School and extended northwest past Buckeye City.

The East Branch was joined below Howard by a tributary from the east which had its head waters in Brush Run in Butler Township. From Zuck the course of this tributary channel extended to the northwest along the valley of the Kokosing River for a distance of about one-half mile. From exposures along the valley at this place there is evidence that a channel now filled with drift formerly extended to the northwest across the neck of land formed by the broad loop to the south of the

[9]Leverett, Frank, U. S. Geol. Survey, Mon. XLI (1902), p. 406.
[10]Idem., p. 401.

present gorge of the Kokosing. The old channel entered the present valley a short distance northwest of the plant of the Millwood Stone Co. and continued along the site of the present channel to the East Branch below Howard. No well data on the thickness of the drift in this tributary valley has been secured. The foregoing conclusions are based on the general thickness of fill in the East Branch near the mouth of the tributary, the direction of flow of Brush Run, and the results of field observations along the gorge of the Kokosing River.

WEST BRANCH OF NORTH FORK AND ITS TRIBUTARIES.

The valley of West Branch of the North Fork of the Newark drainage can be traced by well records with some degree of accuracy from its junction with the East Branch in Morgan Township through eastern Miller and Clinton townships to Mt. Vernon. From here it is believed that the main channel extended to the northwest, passing through the western part of Mt. Vernon in the general direction of the Kokosing River and entered Middlebury Township a short distance west of Fredericktown.

South of Mt. Vernon the valley of the West Branch is filled with drift ranging in thickness at various localities from 260 to 350 feet. The record of the J. W. Campbell well, located in this valley near the northeastern corner of Licking County, shows 329 feet of drift with the upper surface of bed rock at an elevation of about 656 feet. In the Philo Higgins No. 1 well, situated about 1½ miles northwest of the Campbell well, the drift has a thickness of 349 feet and bed rock occurs at an elevation of about 680 feet. The drift has a recorded thickness of 285 feet at the C. A. Lefever No. 1 well, located in this old valley in the southeastern corner of Clinton Township. Near Cherry Hall School the lowest part of the channel is marked by 265 feet of drift lying on bed rock which has an elevation of 745 feet as recorded in the record of Well No. 1 on the W. J. Workman property. On both sides of the valley the surface of bed rock rises rather abruptly to elevations of 900 feet or more on the west and 1,000 feet or more on the east. The average slope of West Branch from Mt. Vernon to its junction with the East Branch is on an average about 11 feet per mile to the south.

Very little drilling for oil or gas has occurred within recent years along the probable course of West Branch northwest of

Mt. Vernon. Leverett reports that a well drilled near the city waterworks and therefore in the old channel of West Branch, penetrated 224 feet of drift before reaching bed rock.[11] As the well head elevation is about 900 feet, bed rock has an elevation of about 766 feet. Rock outcrops occur in the east edge of Fredericktown, but in the western part of town wells obtain water from the drift at depths of about 40 feet. On the hills east of Fredericktown the drift sheet is generally thin. Very little data can be secured relative to the thickness of the drift north of Fredericktown in Middlebury Township. The topography suggests, however, that one channel probably extended to the northwest in the direction of Waterford and a tributary channel to the northeast past Ankertown. A well drilled about one-half mile southeast of Caywood School, Middlebury Township, and near the channel first mentioned, penetrated about 150 feet of drift before reaching bed rock.

The West Branch was joined at Mt. Vernon by a large tributary which entered from the north. This tributary had its head waters in western Pike and eastern Berlin townships and flowed south through the upper part of the valley of Schenck Creek and continued to the south along the site of the valley of Center Run. Thick deposits of glacial material occur along this old valley. About one-half mile southwest of Valley Grove School a well drilled to the Clinton sand near the center of the channel penetrated 226 feet of drift, reaching bed rock at an elevation of about 1,080 feet. Both east and west of this well the upper surface of bed rock rises to heights of 1,000 feet or more above tide or over 150 feet above the bottom of the old channel.

South of Mt. Vernon two tributaries joined West Branch from the west. The first and smaller one entered Miller Township about one mile south of the north boundary and extended from this place in a southeasterly direction past Brandon, joining the channel of West Branch about three-fourths of a mile southwest of Lafayette School. Its course is marked by excessive thicknesses of drift and a comparatively low elevation of the upper surface of bed rock. At the Splinterville School the elevation of the upper surface of bed rock is about 975 feet. At the Miller heirs No. 1 well, one mile due north of the Splinterville School, the elevation of rock is about 975 feet and five-eighths of a mile north of the Miller well it is

[11]Idem., p. 408.

1,040 feet. The Ganet Harris No. 1 well, located along the channel of this tributary five-eighths of a mile northwest of Brandon, showed 260 feet of drift with bed rock at a height of 840 feet above sea level. North and south of the Harris well rock rises to elevations of over 1,000 feet.

The second tributary from the west, which apparently was much the larger of the two, entered the west edge of Miller Township west of Oppossum Street School and followed a course a little south of east past the Vance School. As the slope of this valley to the southeast is small in Miller Township in comparison with other tributaries of this system, it is probable that the valley had its head waters some distance to the west, possibly beyond Blendon Township. A well drilled in this old channel on the Levi Thompson farm, west of Oppossum Street School in Miller Township, penetrated 360 feet of drift before reaching bed rock. A second well near Vance School passed through 324 feet of drift.

The Newark Valley was joined at Hanover by a large tributary from the northeast which apparently had its head waters in Perry Township, Coshocton County, and in Jackson Township, Knox County, and extended along the sites of the Brushy Fork and Wakatomika valleys in Perry and Fallsbury townships, Licking County, and the Winding Fork Valley in Pike and Perry townships, Coshocton County. The topography suggests that a tributary entered this channel from the north along the site of Jug Run in Jackson Township, Knox County, and in Fallsbury Township, Licking County. A second tributary entered from the east along the site of Five-mile Creek in Pike Township, and Wakatomika Creek in northwestern Jackson Township. The old valley floors are now buried beneath thick deposits of glacial outwash. At the Ashcroft well, situated on the side of the valley in Section 21, Fallsbury Township, the drill penetrated 58 feet of drift, reaching bed rock at an elevation of about 742 feet. Records of wells drilled in the old valley at Perryton show alluvial material ranging in thickness from 60 to 160 feet. At the J. E. Seward No. 3 well, located about four-fifths of a mile east of town, the valley filling has a depth of 158 feet, bed rock being reached at an elevation of about 630 feet. No records of the thickness of the drift has been secured southwest of Perryton. Unconsolidated materials also occur in excessive thickness along the eastern tributary in northwestern Jackson Township.

A quarter of a mile west of the Patterson Bridge across Wakatomika Creek, the drill penetrated 99 feet of unconsolidated material before reaching bed rock, while a quarter of a mile southeast of this bridge the record of a well drilled near the center of the present valley shows 40 feet of unconsolidated materials. Wells drilled near Ashcroft Ford also show a great thickness of drift.

SUMMARY AND CONCLUSIONS.

During the Newark stage the drainage of Knox County and the north central part of Licking County discharged to the south into the Newark River through a channel which in Licking County followed closely the site of present North Fork of the Licking River. This channel and its numerous tributaries contain drift deposits of great but varying thickness. Data derived from well borings show no evidence of a divide near Utica, as proposed by Leverett, which would block a southern course for the drainage of Knox County during Newark time.

The divide which marked the rim of the basin of North Fork and its tributaries has not been definitely determined on the west, but it probably passed through western Licking and eastern Morrow counties. On the north it is marked by the highlands which extend across the northern edge of Knox and the southern part of Richland and Ashland Counties, while on the northeast it is represented by Kaylor Ridge in western Knox County and by the high hills of its southern continuation in northwestern Coshocton County. It is believed that this divide crossed the Kokosing Valley near the west edge of Coshocton County.

Through numerous tributary channels now deeply filled with drift the Newark River southwest of Newark received the drainage of southern Licking, northwestern Perry, and northern Fairfield counties. Beyond Baltimore, Fairfield County, the exact location of the Newark channel has not been traced by well borings.

STUDIES OF THE FOOD HABITS OF UTAH LIZARDS.[1]

G. F. KNOWLTON AND M. J. JANES.[2]

During the summer of 1931, 606 lizards were collected principally from desert areas in Tooele and Box Elder Counties, in northern Utah. Most of these were taken on Russian thistle areas near shadscale, sagebrush, or greasewood; most of the collections were made in connection with sugar-beet leafhopper predator studies. Almost the entire food of the lizards consisted of insects, with the addition of some spiders. A much larger number of lizards were examined in 1931 than during the studies carried on during the preceding year.[3]

Most of the lizards were collected with a .22 rifle, using shot shells. After an incision was made in the body cavity, each specimen was preserved in 80 per cent alcohol. The stomach contents were examined microscopically in the laboratory. No attempt was made to identify the large number of insect fragments present in most of the stomachs.

Nearly all of the forms recovered from the lizard stomachs were injurious or of unknown importance. However, beneficial forms, such as *Geocoris decoratus* Uhl. and *Nabis ferus* (L.), predators, and *Pipunculus* sp. parasites upon *Eutettix tenellus* were taken, along with some beneficial Hymenoptera, Diptera and Carabidae.

An analysis of the stomach contents of the two most common forms is given in Table I. Because of the large number of beet leafhoppers consumed,[4] these species are considered as being beneficial in the areas studied.

The stomach contents of the following specimens of the brown-shouldered Uta, *Uta stansburiana stansburiana* (B. and G.), are fairly typical: Specimen (1) collected in a Russian thistle area at Flux (Tooele County), October 19; 3 nymphal *Eutettix tenellus* (Baker), 4 Nysius ericae (Schill.), 1 adult and 1 nymphal *Geocoris decoratus* Uhl., 1 lepidopterous larva and

[1]Contribution from the Department of Entomology, Utah Agricultural Experiment Station. Approved for publication by Director.

[2]Associate Entomologist and Graduate Assistant, respectively.

[3]Notes on Insect Food of Two Utah Lizards. By G. F. Knowlton and M. J. Janes. *In* Proc. Utah Acad. Sci. 8: 140–142 (1931).

[4]The Beet Leafhopper in Northern Utah. By G. F. Knowlton. Utah Agr. Exp. Sta. Bul. 234 (Tech.), (1932).

1 spider. Specimen (2) collected in a Russian thistle area west of Delle, August 14; 8 adults and 1 nymphal *Eutettix tenellus*, 1 *Geocoris decoratus*, 1 *Pipunculus* sp., 1 *Chloropisca glabra* (Meig.), 5 Formicidae, and 7 spiders. One individual (3) taken on June 19 among *Cheirinia repanda* southeast of Timpie, contained an unusual variety of insects consisting of 1 grasshopper nymph, 3 adults and 1 nymphal *Eutettix tenellus*,

TABLE I.

Stomach Contents of *Uta stansburiana stansburiana* (Baird and Girard) and *Sceloporus graciosus graciosus* (Baird and Girard) Collected on Utah Desert Areas, 1931.

Hexapods (Insects)	Total Stomach Contents of 528 Specimens of *Uta stansburiana stansburiana*		Total Stomach Contents of 61 Specimens of *Sceloporus graciosus graciosus*	
	Adult Insects	Immature Insects	Adult Insects	Immature Insects
Collembola	43	0	0	0
Orthoptera	12	44	3	24
Isoptera	114	0	0	0
Odonata	12	0	0	0
Neuroptera	1	3	0	0
Thysanoptera	4	0	0	0
Homoptera	908	656	61	72
Hemiptera	651	190	41	27
Coleoptera	97	4	25	1
Diptera	337	18	8	1
Lepidoptera	24	57	9	17
Hymenoptera	458	12	215	0
Total Insects	2,661	984	362	142
ARACHNIDA (Spiders)	227 and two masses of eggs.		14	
REPTILIA	1 small *Uta stansburiana stansburiana*.			
FOREIGN MATERIAL	Sand, small pebbles, and plant fragments.			

1 Coreidae, 3 *Nysius ericae*, 3 adults and 2 nymphal *Geocoris decoratus*, 1 Pyrrhocoridae, 1 Reduviidae, 4 Miridae including 3 *Melanotrichus* sp.; 4 Formicidae and 3 Sphecidae. One individual (4) collected under a board among Russian thistle at Delle on October 8 contained 87 termites.

Examples of the stomach contents of the sagebrush swift, *Sceloporus graciosus graciosus* (B. and G.) are: Specimen (1)

collected in sagebrush—Russian thistle area south of Hardup (Box Elder County) July 8; 1 *Eutettix tenellus*, 1 *Thamnotettix venditarius* Ball, 2 Carabidae, 1 Tipulidae, 1 Braconidae, 9 Formicidae including one *Formica fusca* Linn. Individual (2) taken in a Russian thistle—sagebrush area at Showell (Box Elder County), September 7; 2 adults and 7 nymphs of *Eutettix tenellus*, 1 Diptera, 1 lepidopterous larva and 1 Sphecidae.

A larger proportion of ants were found in individuals of these two species during 1931 than among those examined during the preceding year, apparently due to a relative scarcity of other insects.

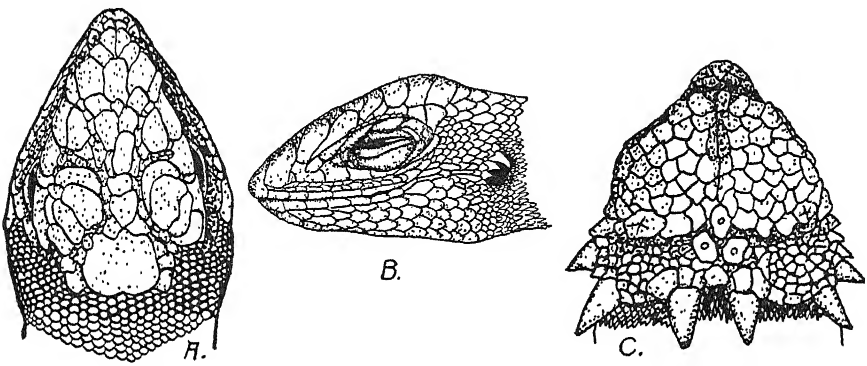


FIG. 1—A and B: Dorsal and lateral views, respectively, of the head of *Uta stansburiana stansburiana* (B. and G.); C: Dorsal view of the head of *Phrynosoma platyrhinos* Girard.

Identifiable insects contained in the stomachs of 528 *Uta stansburiana stansburiana* were:

Order

ORTHOPTERA: Locustidae, 54, including *Trimerotropis vinculata* Scudder 2, *Melanoplus femur-rubrum* (DeGeer) 1; Gryllidae 1.

NEUROPTERA: Chrysopidae, 1.

HOMOPTERA: Membracidae, 10; Cicadellidae, 1,550, including *Agallia sanguinolenta* 55, *Xerophloea viridis* (Fabr.) 1, *Eutettix tenellus* 838 adults and 655 nymphs, *Thamnotettix venditarius* Ball 1; Aphiidae 1.

HEMIPTERA: Pentatomidae, 1; Coreidae, 2; *Lygaeus reclivatus* Say 1, *L. kalmii* Stal 1, *Nysius ericae* 135, *Geocoris decoratus* 386 adults and 155 nymphs; Phyrrhocoridae 1; Reduviidae 1; *Nabis ferus* (L.) 3; Anthocoridae 1; Miridae 151, including *Lygus pratensis* (L.) 134, *Melanotrichus* sp. 3, *Atomoscelis modestus* (Van D.) 5.

COLEOPTERA: Carabidae, 34; Silphidae, 1; Elateridae, 2; Scarabaeidae, 1; Chrysomelidae, 3.

DIPTERA: Culicidae, 1; Stratiomyidae, 1; Tabanidae, 2; Asilidae, 4; *pipunculus* sp., 6; Syrphidae, 1; Tachinidae, 2; Sarcophagidae, 9; Muscidae, 4; *Chloropisca glabra* (Meig.), 99.

HYMENOPTERA: Tenthridinidae, 1; Braconidae, 3; Ichneumonidae, 3; Chalcididae, 26; Formicidoidea, 345; Sphecidae, 5; Dryinidae, 1; Vespidae, 6; Andrenidae, 1; Apidae, 6.

In addition, one large brown-shouldered Uta had swallowed a small individual of the same species.

Identifiable insects contained in the stomachs of 61 *Sceloporus graciosus graciosus:*

ORTHOPTERA: Locustidae, 26; Gryllidae, 1.
NEUROPTERA: Chrysopidae, 1.
HOMOPTERA: Cicadellidae, 127, including *Agallia sanguinolenta* 1, *Eutettix tenellus* 53 adults and 71 nymphs; Aphiidae, 2.
HEMIPTERA: Pentatomidae, 1; Lygaeidae, 41, including *Lygaeus reclivatus* 1, *Nysius ericae* 13, *Geocoris decoratus* 17, *Lygus pratensis* 7.
COLEOPTERA: Carabidae, 3; Coccinellidae, 2; Chrysomellidae, 2; Curculionidae, 1.
DIPTERA: Tipulidae, 1; Sarcophagidae, 1.
HYMENOPTERA: Braconidae, 1; Ichneumonidae, 1; Formicidoidea, 208; Sphecidae, 2; Apidae, 1.

Examination of the stomach contents of nine horned toads, *Phrynosoma douglassii ornatum* (Girard), showed their diet to consist largely of ants; one specimen contained 41, while another possessed 4 ants and 65 ant head capsules. The total for the nine specimens was 161 ants and 157 ant head capsules. Other insects contained were *Trimerotropis vinculata* Scudder 1; *Eutettix tenellus* 1; Carabidae 1; Chrysomelidae 2; Diptera 1; Andrenidae 1.

Stomach contents of six specimens of the horned toad, *Phrynosoma platyrhinos* Girard, consisted mainly of ants. The total insect contents of these was 108 ants and 77 ant head capsules, one specimen possessing 52 individuals. Other insects that had been ingested were *Eutettix tenellus*, 3; Coleoptera, 4, including Coccinellidae 1 and Scarabaeidae, 1; Diptera, 1. The stomach of one specimen contained 5 round worms which apparently were parasitic in the lizard.

A specimen of the desert whiptail lizard, *Cnemidophorus tessellatus* (Say), collected in a greasewood area on the foothills four and one-half miles northwest of Grantsville, May 24, contained 2 Carabidae, 3 larval Elateridae, 1 larval Lepidoptera, and 1 Formicidae.

An individual of *Crotaphytus wislizenii* Baird and Girard taken in sagebrush on the foothills at Hardup, June 24, contained 2 grasshopper nymphs, 1 ant, and numerous insect fragments.

BOOK NOTICES.

Fundamentals of Biology.

This is the second edition of a standard text-book, presenting in a perfectly orthodox manner the basic facts and principles of biology. Little of a controversial nature is touched upon, a fact which makes some of the presentations not strictly up-to-date. For example, no notice is taken of any mechanism of sex-determination other than that of the sex-chromosomes. The list of human hereditary characters is far from modern. Other examples could be mentioned.

The handling of each chapter as a unit, thus facilitating the easy interchange of topics and omission of material on the part of the teacher, is a commendable feature. Many new illustrations have been added. For those who desire a standard orthodox text, the book is quite workable.—L. H. S.

Fundamentals of Biology, by Arthur W. Haupt. x + 403 pp. New York. McGraw-Hill Book Co., 1932.

Botany for College Students.

This is the most recent text to appear in the field of General Botany. Part I, entitled "General Principles," is essentially an elementary treatment of the structures and processes of the seed plants and is a unit discussion in itself. This section is planned for a semester's work in the subject. Part II, planned for a second semester's work and entitled "The Plant Groups," calls the roll of the plant kingdom. The muster is complete. This is essentially a systematic treatment of plant morphology; it adheres closely to the conventional pattern of such presentations. So wide apart are the two sections in point of view and subject matter that each might be regarded as a separate text, but for the fact that both dwell together between the same two covers.

One of the author's reasons for the production of this text is the "evident need of an American textbook which is a general botany in scope as well as in name." Such an assertion treads imperiously into controversial territory. Many botanists would deny this name to a text which is a stranger to all but the names of such vital and dynamic topics as genetics and ecology.

A commendable feature is the wealth of illustrations, practically all of which are original, or especially redrawn for this edition. Almost without exception these are excellent. In addition to the index there is a glossary of the botanical terms used in the body of the text.—B. S. MEYER.

College Botany, by William H. Eyster. 695 pp. New York, Ray Long and Richard R. Smith, 1932.

Hormones and Nerves.

This small book is a most interesting account of the recent and novel hypothesis that the nervous system may secrete hormones which act on muscles, glands, cromatophores and other receptors. The hypothesis is in reality a special application of the general principle of hormones, with the hormones in this case usually traveling very short distances from the point of secretion to that of application. Many interesting recent data are brought to bear on this problem, with careful critical discussions, and the reader cannot fail to be impressed with the intimate connection between hormones and nerves. The author concludes that while "nobody today considers seriously the aphorism that 'the brain secretes thought as the liver secretes bile,' yet if what has been set down in the preceding pages be true, nervous secretion plays a part even in our mental operations such as has scarcely been suspected by the modern physiologist."—L. H. S.

Humoral Agents in Nervous Activity, by G. H. Parker. x + 79 pp. Cambridge Univ. Press (in U. S. A. from The Macmillan Co.). $1.75.

The Evolution of Human Behavior.

Studies of human evolution have of necessity been undertaken largely from the standpoint of man's bodily structure. The present volume is an attempt to approach human evolution from the viewpoint of behavior. The attempt cannot be considered entirely successful since most of the book is given over to discussions of orthodox structural evolution. Nevertheless the result is interesting and somewhat unique. Following a survey of evolution in general, based largely on comparative anatomy, a careful comparison of apes and man is undertaken. Then appears a discussion of the evolution of human culture, based on the author's belief that the differences between man and the apes are mainly cultural rather than biological. Considerable ingenious and plausible speculation is invoked concerning the rise of language and manual dexterity. The differences between present races of man are discussed, largely from a structural viewpoint. The book closes with a chapter on present trends in evolution, including a very sane discussion of eugenics.

The author's speculation occasionally tends to become dogmatic. The statement that "the tri-dactyl foot of the horse is forever lost to the species because of the specialized monodactylism that later evolved" should be compared with Stockard's recent work on dogs. The belief that skin color and similar characters possess no survival value might be open to question. The dogmatic pronouncement that modern warfare is markedly dysgenic is at least a debatable question in the light of recent researches such as those of Gini and Hunt. The author's explanation of heterosis is not the last word on the subject.

The book is, however, a valuable pioneer in the attack on the evolution of human behavior, and as such should be carefully read by every serious student of biology.—L. H. S.

The Evolution of Human Behavior, by Carl J. Warden. ix + 248 pp. New York, The Macmillan Co., 1932. $3.00.

Organic Chemistry.

A text designed for a short course in the theory of Organic Chemistry, together with instructions for a laboratory course to accompany the lectures. The condensation of the general subject of organic chemistry into slightly more than 200 pages, with 60 pages devoted to fats, carbohydrates, proteins and dyes, does not permit much choice of subject to discuss or deviation from the "beaten path" of theoretical organic chemistry. The author presents his subject in the more or less accepted order of saturated hydrocarbons, alcohols, ethers, halogen derivatives, unsaturated hydrocarbons, aldehydes, ketones, acids, fats, dibasic acids, carbohydrates, amines, proteins, cyclic nitrogen derivatives, aromatic hydrocarbons, phenols, acids, aromatic nitrogen derivatives, and dyes; together with 35 pages of laboratory directions covering some 28 experiments in both aromatic and aliphatic chemistry. The laboratory exercises are well selected and should give the student a good technical training in manipulation and an insight into the characteristic aliphatic and aromatic reactions.

The theoretical portion of the text, in spite of the space limitation, is well prepared and in excellent typographical form. There is an absence of tabular material, particularly in the alcohols. In the first part of the book the emphasis has been placed on individual compounds, rather than on class reactions and homologous series; hence there is very little use of functional groups and type reactions (with the use of the symbol R for any alkyl radical). The section on dyes requires, for a proper understanding, a more comprehensive knowledge of organic chemistry than is obtainable in the previous material in the text. The sections on carbohydrates and proteins, while over emphasized, are well prepared and should make the text particularly useful for a short organic course for students in the biological sciences, where such emphasis is to be expected. Another departure from other similar texts is the omission of proper names, both in regard to important theories and discoveries and to reaction names. The use of the laboratory portion of the text is optional, the book being quite suitable for courses without laboratory instruction.—W. R. Brode.

An Introduction to Organic Chemistry, by Ira D. Gerard. vi+296 pp. New York, John Wiley and Sons, 1932. $2.75.

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PRE-CAMBRIAN IN OHIO.*

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INTRODUCTION.

This probably is the largest topic on our program, about as large a topic as one could select in Ohio. And yet, the subject contains about as little that is really known as any subject one could choose. The material presented here is a by-product of my work on the Physiography of Ohio, where a knowledge of the ancient physiographies of the state is not only interesting, but essential. In consultation with our State Geologist he gave permission to present it and even urged its publication before the bulletin shall be printed. Such a procedure has a double advantage. It brings whatever there is of value before us all some time before it can now possibly come out in the bulletin, and it gives us an opportunity to discuss the problems before publication in a more permanent form. The material to be examined divides easily into three parts which become the section headings used.

PRE-CAMBRIAN SURFACE.

Essentially everywhere in Ohio where older sedimentary rocks are exposed, along the Cincinnati arch and particularly in southwestern Ohio, the rocks are in layers with very low angle dips often so nearly horizontal that without leveling instruments no dip can be detected for miles. Scores of wells in the southwestern quarter of Ohio reach the level of the Trenton beds, the lowest strata exposed in Ohio, and always they are reported present and thus shown to be essentially continuous and at similar depths. It is upon the Trenton

*Presented before the Geologic Section of the Ohio Academy of Science, April 29, 1932, Delaware, Ohio.

that the Cincinnati anticline structure is best mapped. In the northwest quarter of the state hundreds of wells have been drilled to the Trenton and the continuity and general depth are found. This can mean at least one thing concerning the pre-Trenton surface, that it was not very rough but rather notably smooth and level when the Trenton materials began to accumulate. Some few wells in western Ohio go through the Trenton and the same simple structure and levelness of beds is also found below. The only departure is the broad, low arch of the Cincinnati anticline which is known to owe its origin to post-Trenton movements.

But in addition to these many wells which end in Trenton and in rare cases in Cambrian with a goodly number stopping in strata of lower Ordovician, we now have several wells that go through all sedimentary material into underlying metamorphics. Data pertinent to our study have been collected and will be stated here.*

The first well to go through was at Findlay and was drilled in 1912.† It penetrated 210 feet into granitic gneiss after going through 2770 feet of sediments. The head of the well has an elevation of 830 feet. Hence the Pre-Cambrian surface at Findlay is 1940 feet below sea level. Two wells a few miles apart in different townships were drilled, but they gave essentially parallel records which are here treated as one well. Another well going through is at Woodville, about 30 miles northeast of Findlay. This one reached granitic gneiss at 2672 feet and penetrated 150 feet. The head of this well is 655 feet above sea level so the Pre-Cambrian surface at Woodville is 2017 feet below sea level. A third well located near Tiffin reached the granitic gneiss at 2950 feet. Since the well-head is at 760 feet above sea level, the Pre-Cambrian surface there is 2190 feet below sea level. The Tiffin well is 28 miles almost directly east of Findlay and 25 miles S. by S. E. from Woodville. These three occupy the corners of a triangle 25, 28 and 30 miles on a side.

Findlay and Woodville are almost on the Cincinnati anticline axis, and at these two places the Pre-Cambrian is nearly at the same altitude, 1940 and 2017 feet below sea level, a

*Dr. Wilber Stout, State Geologist of Ohio; Dr. J. E. Carman, of Ohio State University, and Mrs. Theron Wasson, formerly with the Pure Oil Company, have assisted in bringing these data together. Specific reference to published data can be given for two or three wells.

†American Journal of Science, Vol. 35 (1913), pp. 124–130.

descent of 77 feet in 30 miles. The top of the Trenton descends 187 feet in the same distance. The Tiffin well is down the east slope of the anticline and the Pre-Cambrian surface is at 2190 feet below sea level which gives a descent down the anticline of 250 feet in 28 miles.

At New London, 43 miles east of Tiffin, hence farther down the east flank of the anticline, another well was drilled in 1925. This well reached the Trenton at 3645 feet and penetrated 756 feet of Trenton, but drillers believed they did not go quite through this formation. The well-head is at 991 feet above sea level, hence the top of Trenton is 2654 feet below sea level. Here we have a dip of the Trenton eastward from Findlay to New London of 2319 feet in 71 miles, or 32+ feet per mile. The Pre-Cambrian slope from Findlay to Tiffin is nearly 9 feet per mile, no doubt becoming steeper toward Tiffin. Other wells reaching the Trenton in this part of the state indicate its planeness and its even dip from the vicinity of Tiffin eastward. It may be fair to assume that the Pre-Cambrian follows the Trenton slope down eastward as closely as it follows in the three wells on the triangle. Certainly there is no evidence against this assumption. Such assumption would place the Pre-Cambrian surface at New London at 4259 feet below sea level.

These four wells have found no unevennesses in the Pre-Cambrian surface except those exactly correlated with the Cincinnati anticline. All wells that have stopped in the sediments from the Trenton down have failed to encounter any Pre-Cambrian elevations or thinning of the sedimentary strata as if lying over a Pre-Cambrian hill. This again suggests notable evenness of the Pre-Cambrian surface over this Findlay-Woodville-New London portion of the state.

At South Charleston, 84 miles almost directly south of Findlay and some miles down the east flank of the Cincinnati structure, is the Friend well drilled in 1926-7. The well-head is 1100 feet above sea level. The Trenton was reached at a depth of 1245 feet or 145 feet below sea level. Its thickness was 610 feet, about 120 feet less than in the Findlay region and about as much thinner as found at Waverly in a well to be discussed shortly. The Trenton is 190 feet higher here than at Findlay, an ascent of 2¼ feet per mile, but it rises southward along the axis of the anticline faster than on this N-S line. Below the Trenton was found 800 feet of Ordovician,

665 feet of upper Cambrian and 99 feet of red clastic material, probably middle Cambrian. Thus these sediments continue downward 2319 feet below sea level. The drill next passed through 421 feet of material classed by those who studied it as Upper Keweenawan, and then through 807 feet of black carbonaceous limestones. If these 1228 feet are Pre-Cambrian, the surface we are describing is here about the same depth as at Tiffin—remarkably near the same. Even if all these 1228 feet are Cambrian, which seems a much more probable interpretation to one who has not seen them, and the Pre-Cambrian surface is not far below them, then our Pre-Cambrian surface is some 3547 feet, or a little more, below sea level. Such an interpretation is wholly consistent with the Paleogeographic maps which show the Cambrian seas spreading over Ohio from the south as early as Middle or possibly late Early Cambrian time.

On this more generous interpretation the Pre-Cambrian surface would be placed some 3600 feet below sea level at South Charleston, not as deep on this eastern flank by 600 feet as it surely is at New London. Nor is South Charleston as far down the flank. But with all this increase in depth from Findlay to South Charleston, 1600 feet in 84 miles, we here have only feeble relief, less than 20 feet per mile and much of this is to be accounted for by the position of the South Charleston well with reference to the Cincinnati arch.

For years the Waverly well* drilled about 1910 was interpreted as having reached crystalline rocks called serpentines but in recent years there has been much doubt about this interpretation. In this well near Waverly the Trenton was 729 feet thick and was struck at a depth of 2100 feet. Since the altitude of the well-head is 600 feet, the Trenton was found at 1500 feet below sea level. From South Charleston to Waverly is 60 miles nearly directly down the east flank of the anticline. With the Trenton below sea level 145 feet at the former town and 1500 feet at the latter, the rock dips 22–3 feet per mile. With the Upper Keweenawan (Pre-Cambrian) at 2319 feet below sea level at South Charleston, and the structure descending 22 feet per mile as it does on the Trenton, the Pre-Cambrian could hardly be less than 3674 feet below sea level at Waverly. These so-called serpentine fragments were found at 2720 feet below sea level.

*American Journal of Science, Vol. 31 (1911), pp. 19 ff.

Again, if the so-called Upper Keweenawan and black carbonaceous limestones of South Charleston are also present at Waverly, as seems reasonable on the grounds of an invading Cambrian sea from the south, one could not expect to find Pre-Cambrian higher than 4183 feet below sea level. Thus it seems very probable that whatever the material is that has been called "serpentine fragments" it cannot be Pre-Cambrian. The Pre-Cambrian at Waverly probably will be found over 4000 feet below sea level.

By similar reasoning from the depth to Trenton in southern Ohio, the Pre-Cambrian would have been reached in the Ironton well at not less than 5250 feet below sea level, for the Trenton was found there at 2670 feet below tide.

Summarizing the above paragraphs, we have Pre-Cambrian known at Woodville at 2017 feet below sea level, at Findlay at 1940 feet, and at Tiffin at 2190 feet. Calculating its depth below the Trenton as great as it was found in the three wells New London may have Pre-Cambrian at 4259 feet below sea level. South Charleston has Pre-Cambrian at 2319 if the materials are truly diagnosed as Keweenawan, but a better interpretation seems to place the Pre-Cambrian a little lower than 3547 feet below sea level. These depths find no inequalities in the surface of the old rocks except such as are due to the up-warping of the broad geanticline. Hundreds of wells scattered over western Ohio reaching Trenton or deeper likewise find no other inequalities. Therefore it seems safe to assume that this Pre-Cambrian surface is very remarkably even and smooth with slopes of not more than 2–10 feet per mile except those down the flanks of the anticline. Such a surface across crystalline rocks can be none other than an erosion surface. To have been an erosion surface it must have been much higher than it is now and somewhat, though but little, above sea level. But to consist of such rocks as are found in it, there must once have been hundreds of feet of rock above this Pre-Cambrian surface. Hence, there must have been great Pre-Cambrian erosion to peneplanation in Ohio. Such an erosion surface has been widely recognized elsewhere and the time required to make it has been called the Lipalian interval.

Some support for this interpretation of the character of the Pre-Cambrian surface is found in a well which reaches granite at about 3000 feet below sea level at Amboy, Illinois.

Much more support comes from the gradual disappearance of a similar Pre-Canbrian surface exposed in Canada, Wisconsin, and Minnesota, but sloping down under late Cambrian sediments in Canada and in more southerly parts of these two states. With such gentle decline below younger rocks this surface would reach the depths where we find it in Ohio.

PRE-CAMBRIAN MATERIALS.

This section has much less to offer than the former. Only three wells in Ohio have positively reached the Pre-Cambrian. Each seems to have found red granitic gneiss. If the South Charleston well has reached it, the material is partly clastic, partly limestone, and the latter is not metamorphosed. Diabase dike in sediments and underlain by over 100 feet of Keweenawan is reported in the Greentown well in central northern Indiana at about 3000 feet below sea level.

Perhaps the best evidence we have of the nature of our Ohio Pre-Cambrian materials is in the nature of the known Pre-Cambrian in the north which has been shown to descend as a peneplain beneath the Cambrian and other sediments of these north central states. Everywhere in these northern exposed areas the rocks are crystalline, metamorphosed sediments and tuffs with intrusions and extrusions of granitic and basic material. Our Ohio foundation is known to be Pre-Cambrian, because the Cambrian as unmetamorphosed sediments overlies it everywhere. Hence, in Ohio the rocks which carry this old Pre-Cambrian surface are probably everywhere similar complex crystallines.

Another item suggesting the nature of the materials may be had from the Pre-Cambrian in Canada. Here it is the carrier of several valuable mineral and ore deposits and a large variety of economic materials. The great iron deposits of the Lake Superior region, the copper of the Keweenaw Michigan section, the Sudbury nickel, silver and gold, the cobalt ore, small deposits of gold in a number of places separate from the other metallic ores, asbestos, serpentine marble and a wide variety of good building stones represent both metallic and nonmetallic value in the exposed Pre-Cambrian. Our three or four wells that actually reach Pre-Cambrian in Ohio reach nothing of metallic deposits, but they do reach rock that would be good building stone. The 2000–3000 feet of cover however is sufficient barrier to its economic development.

PRE-CAMBRIAN STRUCTURES.

The third part of this paper concerns itself with structures of Ohio Pre-Cambrian. A suggestion from the exposed rocks of similar age in our Canadian area is our best lead at present. If, as shown and generally believed, the Pre-Cambrian of the north continues underneath the Paleozoic of Ohio it is reasonable to believe that it carries similarly complex structures. But it is just as true that, from this method of reasoning, we can get no clew as to just what structure is where. The pattern is far too intricate, too confused one pattern with another, to infer safely that because a certain structure occurs near the border of the Paleozoic cover its continues 100 miles beneath that cover.

We really have very little suggestion from our wells concerning structure in these old rocks. Three wells in the Findlay-Tiffin-Woodville triangle found very similar granitic gneiss. One might well infer a mass of granitic gneiss in that locality 30–40 miles across, but one cannot well go farther. The well at Greentown, Howard County, Indiana, some miles north of the capital, is reported passing through a diabase "dike" 20 feet thick in the Keweenawan; but we do not know whether it was pierced at right angles so as to give the exact thickness, or very obliquely so as to make a 20-foot section in a dike only a few feet thick. Diabase dikes may occur in other places.

There are now in use several Geophysical methods of studying covered materials and structures. They are not so well perfected that they tell indisputably what occurs below, but they are well worth considering in the exploration of Ohio Pre-Cambrian. Within the last few years the new Hungarian government through the late director of its Geologic Survey, Dr. Hugo de Boeckh, has made a survey of the covered rocks below the plain and has found what the director considers good evidence of several structures in the ancient rocks below the great unconformity. In a conversation regarding the Ohio situation, he said he felt a survey of western Ohio through 2000–3000 feet of sediments, so well-known as ours now are, would be possible and worth while.

Iron deposits might be located by magnetic methods; certainly no mining should be started unless magnetic methods suggest it. Drilling is always in order. Copper bodies,

metallic and sulphide ores, cobalt and nickel ores may be detected by certain electrical methods in which the potential field is measured. Here again no mining should be started until the geophysical testing suggests it. Our methods are not sufficiently perfected to assure one of actually finding ore bodies even when the measurement of the magnetic and electric properties suggests their presence, because other conditions besides proximity of ore bodies produce differences in potential fields. But study of methods and exploratory surveys are now in order and should be carried on as time and means make possible.

Such ore bodies as the Sudbury and Cobalt in Canada are workable in shafts 2000–3000 feet deep. As the iron ores of the Lake Superior region decline, such bodies as they are at the surface might be worked through a cover of 2000–3000 feet. Probably we could not afford to work an Ohio iron-ore body at such depths *now*, even if we should find one; but no doubt the time will come when we shall be glad to work through the Paleozoic cover for iron, copper, nickel, silver and gold. All of these metals are well known in Pre-Cambrian where it is exposed north of our Paleozoic cover, and may be found in the future under our own Ohio soils.

Respiration in Plants.

This is the title of the latest volume to appear in the Dial Press series of monographs on biological subjects. Messrs. Stiles and Leach attempt to encompass within the covers of this little book a modern, consistent, and condensed treatment of the process of plant respiration. The subject matter is discussed under four chapter headings, to-wit: I. Introductory, II. Respiration of normal plants under aerobic conditions, III. Anaerobic respiration, and IV. The mechanism of respiration. The book is well-rounded, concise, and readable. Perhaps inevitably the authors' evaluation of the subject follows somewhat the temper of their own scientific outlook. Nevertheless, this volume is the only modern treatment of the topic of plant respiration with the exception of Kostychev's well known monograph, which it far excels for the many who prefer to do their reading where the essence of the subject has been distilled out of a mass of otherwise very confusing data. There is a list of the literature cited in the text; this is a short but good working bibliography of the subject. A subject-author index completes the volume. The book deserves a careful reading by every advanced student of botany or biology.—B. S. MEYER.

Respiration in Plants, by W. Stiles and W. Leach. 124 pp. New York, The Dial Press, 1932.

ANCIENT DRAINAGE BETWEEN THE OLD CUYAHOGA AND THE OLD PITTSBURGH RIVERS.*

ROBERT SCRANTON AND G. F. LAMB.

The area involved lies between Willoughby, on Lake Erie, on the north, and the headwaters of the Mahoning, on the south. So far as has been known up to the present, the history of the Mahoning river was uneventful. That the old Pittsburgh River flowed by Beaver Falls, Newcastle, Sharon, Youngstown, Warren, and on northward, has long been recognized, and it was thought that the Mahoning joined it at or near Leavittsburgh. It was known that the present Mahoning flows on glacial till from its headwaters to a point about three miles north of Alliance; that from there to Lake Milton it is generally on rock, although crossing several times zones of till, with considerable depths of fill known near the course; and that between Lake Milton and Newton Falls it is on till, at Newton Falls on rock, and thence to Leavittsburgh on till. It was therefore assumed that the preglacial and interglacial courses had been maintained with variations until the present time.

It was on this assumption that the work of definitely plotting the course was begun in the fall of 1931, under the direction of Professor G. F. Lamb of Mount Union College, by Glenn Goss, Austin Schadle, and Robert Scranton. Exploration of the river course itself from its headwaters for about twelve miles downstream confirmed what had been thought before concerning this section. Well records at Alliance showed a depth of as great as two hundred feet, placing the rock floor at about eight hundred forty feet above tide. Another well in the valley of the tributary Beech Creek showed till to a depth of three hundred feet. This part of the river flows consistently on till, with rock at or near the surface on each side of the valley. The first surprise came where the river turns eastward, crossing the Lexington Road about three miles north of Alliance. At this place, at a bridge

*Read before the Ohio Academy of Science, April 29, 1932, under the title "Drainage Changes of the Upper Mahoning River."

about a quarter of a mile south of the county line (see A. on Map I), drillings revealed that on the west side of the road rock was struck at one hundred forty feet, but on the east side, thirty feet distant, rock lay at ninety feet. This developed into a focal point.

For from that time on, no depth could be found in all the region north or east of this point, east of Atwater and south of Palmyra, which comes at all close to the level necessary to handle any drainage whose level is eight hundred forty at Alliance. The river's course, it is true, is on fill in spots, but the fill is shallow, apparently representing mere irregularities of surface on a rolling rock topography.

Very careful combing of the region revealed what at first seemed to be two leads. One is a till filled valley extending south from Newton Falls, to just east of Palmyra, but no trace of it could be located south of the latter village. On the contrary, the rock is well up. The second is a deep, filled valley leading south on Silver Creek from a point just west of Wayland. It seemed to lead south toward the Atwater region by passing east and south of Edinburgh, but ended southeast of there.

On the other hand, a few wells showing good depth were picked up northwest of the Lexington Road bridge, north of Limaville, at Atwater, west of Edinburgh and near Rootstown Station, and near Campbellsport, which is situated on the West Branch of the Mahoning, southwest of Ravenna. All these wells indicate a considerable depth, quite capable of handling any level to the south. They all lie on an axis bearing northwest from the bridge toward Ravenna.

Inasmuch as it was known before hand that there is a deep till-filled valley along the course of the West Branch, it was then thought that the course of the preglacial Mahoning might have been from Alliance to Ravenna, thence eastward to Newton Falls, although the anomaly of such a sharp turn in midcourse was recognized. Investigation seemed at first to indicate a slight fall of the rock floor in this valley, from west to east. No rock was found, all wells being in drift, but successively deeper wells eastward seemed to justify the idea. However, at Newton Falls, there loomed up a barrier. No depth could be found south of Newton Falls, or northwest of the town, capable by from eighty to one hundred feet of handling the depths consistently shown heretofore. The most ex-

haustive field work showed that no deep valley does exist connecting the valley of the West Branch with that of the old Pittsburgh. The rock floor to the west lies at seven hundred fifty feet above tide, but the very lowest point near the Falls is at eight hundred thirty feet above tide. The prevailing level was slightly above this, but no deep narrow valley could be present, as abundant well data proved.

Frustrated at this point, investigation turned west. Traces had been found of a valley north of Campbellsport, east of Ravenna, and it was hoped that this might offer a solution, but wrongly. Westward from Campbellsport, however, there is evidence of an old filled valley. A series of wells indicate that the rock level dips from north and south into a filled valley lying just south of Ravenna leading toward Kent. Other shallow wells show only glacial drift. But just east of Kent a deep well reveals the rock floor at seven hundred seventy-eight feet above tide. Although there is not all the data that one could desire west of Ravenna, yet the data available indicates the presence of a deep valley, and the well at Kent shows the rock floor sufficiently low to care for the valley depth northward from Alliance.

North of Kent, going was easy. Remarkable depths were found at Twin Lakes, west of Streetsboro, Geauga Lake, East of Solon, at strategic points around Chagrin Falls, at Gates Mills, Eagle Mills, north to Pleasant Valley, which is on the Chagrin River about five miles south of Willoughby. These depths occur between rock walls which appear at or near the surface on the east and west for practically the whole distance. The rock floor seems to drop consistently from about seven hundred feet above tide at Geauga Lake to five hundred twenty-five feet above tide at Wilson Mills and five hundred seventy-five feet above tide at Pleasant Valley.

At this point, however, another apparent barrier was struck. This is in keeping with the findings of the late Professor Cushing. Absolutely no till was to be found north of Pleasant valley lower than six hundred thirty feet above tide. As a matter of fact, further investigations revealed that the depths at Pleasant Valley, close to five hundred seventy-five feet above tide, could not be positively connected with the depths at Wilson Mills to the south. There seems to be a hole at Pleasant Valley, although this could not be established certainly. In view of the consistent fall of the rock floor

from the south, this was most surprising, and it must be admitted, disappointing.

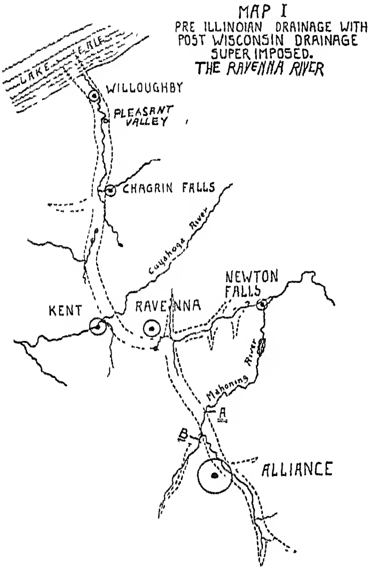
Attempts were made to establish a connection from the Chagrin Valley near Pleasant Valley to a till filled valley found to extend south of Mentor. The latter was the old valley of the East Branch of the Chagrin River, to the east. No joining to the two could be made. It was also attempted to establish a valley northeast from Chagrin Falls along the valley of the East Branch of the Chagrin, but this failed. A lead was followed beginning from a point south of Chagrin Falls, through Solon. A channel was established westward, but its floor ascends toward the west, and it ends just west of Randall. It is thus made clear that the passage was not west by Solon. A stark cul-de-sac in every direction seemed to exist.

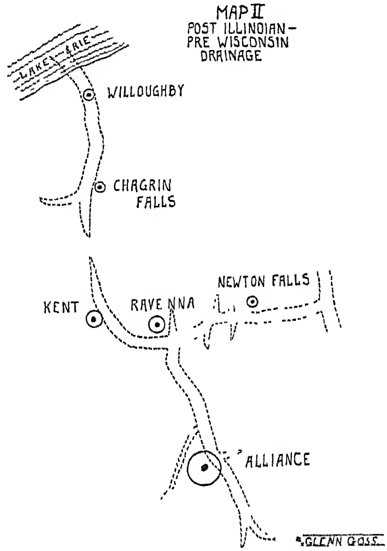
An explanation was begun based on the principle of glacial scour. For it is not necessary to assume that the extreme deepening of this and other channels was accomplished entirely by stream action. A clue was found later in a small valley extending east of Pleasant Valley. Here the small stream is flowing on Illinoian drift and on rock. This indicates that the stream, which had eroded a pre-Illinoian valley, had taken its bed down to a level of above seven hundred feet above tide. It was then interrupted by Illinoian glaciation, and in the time since has been able to reduce its bed only to pre-Illinoian Level. Furthermore, field evidence indicates that the deep inner valleys of the various pre-glacial streams of the region were excavated after earliest glaciation, but before the Illinoian.

Thus it would seem that the extreme depths to five hundred seventy-five and five hundred twenty-five feet above tide were not made by stream action, but by glacial scour. This is corroborated by the apparent pocket at Pleasant Valley. Here the valley is about a quarter of a mile wide. The rock is at the surface on the surrounding high ground, approximately one hundred feet or more above the river. Drift is found as far down as one hundred feet below the river, in some places in a nearly vertical drop. The northern end is practically a vertical drop of one hundred feet from river level, and the southern end seems to be blocked off by a rock floor lying higher than the lowest depths. Other corroboration is to be found in the peculiar depth of three hundred feet on

Beech Creek, near Alliance (see B on Map I), in some otherwise inexplicable depths on the West Branch of the Mahoning, and in other scour features of the region.

According to this hypothesis, the drainage lines of the Tertiary toward the north were resumed after early glaciations, up to the Illinoian. Prior to Illinoian, there was a river whose course was from the region of the present headwaters of the Mahoning, passing by Alliance, Ravenna, Kent, Chagrin Falls, and Willoughby, into the Lake Erie Basin. At Ravenna it





received a stream flowing westward in the valley now occupied by the West Branch, and in addition, probably another stream from the southwest. Since the river headed in the same region as the present Mahoning and was cut by several modern lines of drainage, and parts of its course are included by several modern lines, it is obvious that a distinctly individual system is being considered. It may be called the Ravenna River, since Ravenna is at the conjunction of its principal tributaries and at the midpoint of its course. It is shown on Map I.

The Ravenna River was not permanently diverted until Illinoian time, when it was forced before the ice front to a new outlet through the valley of the West Branch, passing south

of Newton Falls, probably, where it broke over a divide and proceeded into the old Pittsburgh River. This second course was maintained through Illinoian time. It is thought that the Illinoian terminal moraine lay to the north of Ravenna, as no Illinoian till has been found as far south as that town, so that on the retreat of the ice sheet the moraine formed a divide that maintained the eastward diversion through the followed interglacial stage as illustrated on Map II.

In that part of the area in question north of the terminal moraine, it is thought that the greatly diminished drainage was barely able to cut through the Illinoian till and therefore the rock floor in the vicinity of Willoughby and southward was lowered little if any before the Wisconsin advance.

The proposed course of the river from early Illinoian to Wisconsin is based on the following points. First, the present course from about three miles north of Alliance to Pricetown is obviously a new channel. Second, there is a definite ancient channel from Alliance to Campbellsport and eastward passing Newton Falls, over a divide. And third, we have no reason for believing that the Illinoian ice sheet ever reached farther south than a few miles north of Ravenna.

The second drainage was disturbed by Wisconsin glaciation. Till carried and dropped by this ice sheet obliterated the valley from Alliance to Ravenna. On the retreat of the ice, the waters found their way out by their present course, from Alliance directly to Newton Falls.

Evolution.

A scholarly presentation of the basic facts supporting the theory of evolution, written in an exceedingly readable style. The subject is discussed largely from the modern genetic view-point. Following an introductory explanation of chromosomes and the chromosome hypothesis of heredity, attention is directed to the influence of selection, natural and artificial. A discussion of mutation is included. Embryonic development, including a critique of the recapitulation theory, forms the basis for an interesting chapter, followed by a thoroughly scientific attack on the inheritance of acquired characters. Evolution in its relation to the human race is discussed, and the book closes with a valuable presentation and comparison of various mechanistic and metaphysical theories of evolution. The volume is highly recommended for the general reader and the serious student of biology.—L. H. S.

The Scientific Basis of Evolution, by T. H. Morgan. 286 pp., incl. bibliography. New York, W. W. Norton and Co., Inc., 1932.

THE GENUS TEMNOGAMETUM.

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The genus Temnogametum was established by W. and G. S. West in 1897 to include those species of the *Zygnemaceae* with vegetative cells and chromatophores similar to those of *Mougeotia*, but in which the gametangia are clearly differentiated from the vegetative cells prior to conjugation.

Czurda* has called attention to the well known fact that conjugation always occurs between youthful cells, and he therefore concludes that the lengths of conjugating cells (gametangia) are of no significance. Such cells would probably elongate the same as vegetative cells were it not for the organization of gametes and subsequent conjugation. In the one species of Temnogametum that I have seen there is abundant evidence that the gametangia do not elongate when conjugation fails. Furthermore these short cells are not to be identified with the occasional or rare short cells that every experienced collector has seen in field collections and which Czurda figures from his clone cultures.

A second reason advanced by Czurda for not recognizing *Temnogametum* as distinct from *Mougeotia* is his claim that lateral conjugation is the same in both genera. What I have described and figured as "aplanospores" in the paper on "The Genus Mougeotia"† he interprets as zygospores formed by lateral conjugation. This interpretation rests on an observation of a case of lateral conjugation in a clone approaching *M. viridis* in form. I do not question this observation, but I have watched the formation of these spores in several other species, and particularly in *M. prona*, where I had essentially a pure culture in a small spring near Cold Spring Harbor, L. I. No other algae were present except a few species of desmids. For six weeks I made collections at frequent intervals and examined them in the living condition, and had them developing in glass dishes in the laboratory. During that period I examined

*Czurda, Viktor. Zur Morphologie und Systematik der Zygnemalen. Beih. zum Bot. Cent. 48: 2; 238. 1931.

†Ohio Journal of Science, 26: 311–338. 1926.

several thousand spores in all stages of development with this particular point in mind, but I never saw the nucleus divide nor any suggestion of a division of the cytoplasm and formation of a dividing wall.

But even granting that the "aplanospores" figured by Wittrock, Borge, West, and myself are in reality zygotes formed by the union of two partially developed gametes, the whole process is quite different from that which takes place in *Temnogametum.* In *Mougeotia* the contents of a long vegetative cell contracts to the middle of the cell leaving behind a certain amount of cytoplasmic residues. Cross walls are then formed separating this median cell (sporangium) from the two non-living ends of the cell. Czurda thinks this follows a division of the protoplasm and that the median cell is the result of a subsequent union.

In Temnogametum, on the other hand, two adjoining vegetative cells cut off gametangia adjacent to one another with a primary cell wall separating them. The vegetative cells on either side of the pair of gametangia remain alive, and the gametangia accumulate foods and become very dense as compared with the vegetative cells from which they were cut off. Then the primary separation wall is dissolved and the two gametes formed from two distinct vegetative cells unite and form a zygote. Surely this is a very different process from that which occurred in Czurda's clone culture of *M.* (?) *viridis.*

For these reasons I cannot accept Czurda's proposal to merge the species of *Temnogametum* with *Mougeotia.* I agree that they are evidently closely related, but are sufficiently distinct, morphologically and physiologically, to merit separation in different genera.

At present only three species are known: one from Welwitsch's collections in Africa, one from Ule's collections in Southern Brazil, and a third from Thaxter's collections on the Island of Trinidad. Thus far the species are tropical or subtropical in their occurrence.

The genus and species may be defined as follows:

Temnogametum W. & G. S. West, 1897.

Vegetative cells cylindrical, 2 to 25 diameters long; chromatophore an axile plate containing several or many pyrenoids; isogamous gametangia distinct and cut off from the ends of vegetative cells; conjugation scalariform or lateral, resulting in the formation of two

types of zygospores. Aplanospores and parthenospores also formed in some of the non-conjugating short cells. In none of the collections thus far seen has there been a separation of the spore wall and sporangium into distinct layers.

1. *T. heterosporum* W. & G. S. West, 1897. African Freshwater Algae, Jour. Bot. 35: 37. Pl. 370, Figs. 5–9; G. S. West, Algae, pp. 340–341, Fig. 212. 1916; Czurda, Zygnemales; Susswasserflora Mitteleuropas; 9: 98. 1932.

Diameter vegetative cells 14.5–17μ, length 6–12 diameters, chromatophore with 1–6 (usually 5) small globular pyrenoids arranged in a single row; gametangia 22–40μ in length; zygospores, formed by scalariform conjugation cruciate with convex sides and truncate angles, occupying the gametangia and tube, 39–50μ $\times$ 48–59μ; zygospores formed by lateral conjugation obliquely ovoid with truncate ends occupying the united gametangia 20–26μ $\times$ 61–67μ; spore wall smooth, colorless. Plate I, Figures 9–13.

Morro de Lopollo, Angola, Africa, Feb., 1860. Welwitsch.

2 *T. uleana* (Moebius) Wille, 1909. Pflanzenfamilien, Nachtrage zum 1 Teil, 2 abt., page 13, Fig. 3; Moebius, Ueber einige brazilianische Algen, Hedwigia 34: 175–177, Pl. II, Figs. 1–10. 1895. Czurda, Zygnemales; Susswasserflora Mitteleuropas: 9: 97. 1932.

Diameter vegetative cells 10–12μ, length 6–10 diameters, at time of conjugating elongating to 20–25 diameters, cell sap purple; chromatophore an axile plate with usually four pyrenoids; gametangia 20–30μ long; zygospores usually formed by lateral conjugation, obliquely ovoid to ovoid, 20–40μ $\times$ 40–60μ; the less frequent zygospores formed by scalariform conjugation cruciate-quadrate with truncate angles 25–40μ $\times$ 30–50μ; spore wall smooth and colorless (spore dimensions estimated from Moebius figures). Aplanospores formed in the short cells rarely. Plate I, Figures 1–8.

Agulhas Negras (alt. 2,500 m.), near Itajahy, Southeastern Brazil, March, 1894. E. Ule.

Temnogametum thaxteri sp. nov.

Diameter vegetative cells 39–45μ $\times$ 220–360μ (—510μ), (5–10 diameters long), cell sap purple, chromatophore with 30 to 120 pyrenoids, gametangia 36–90μ long; zygospores formed only by scalariform conjugation, quadrangular ovoid with truncate or rounded corners 60–75μ (—100μ) $\times$ 90–120μ; occasionally formed in pairs by union of two pairs of gametangia, each zygospore being somewhat narrower and longer; zygospore wall thick, smooth and colorless; aplanospores may develop within the short cells, which become more or less enlarged, ovoid, about 60μ $\times$ 75μ, with wall similar to that of the zygospores. Plate I, Figures 14–20.

Sandy pools in Aripo Savanna, Cumuto Station, Trinidad, B. W. I., April 10, 1913. R. Thaxter.

EXPLANATION OF PLATE.

Figs. 1–5. *Temnogametum uleana.* Stages in the formation of zygospores by lateral conjugation. After Moebius.

Figs. 6–8. *T. uleana.* Zygospores formed by scalariform conjugation. After Moebius.

Figs. 9–13. *T. heterosporum.* Lateral and scalariform conjugation. After West.

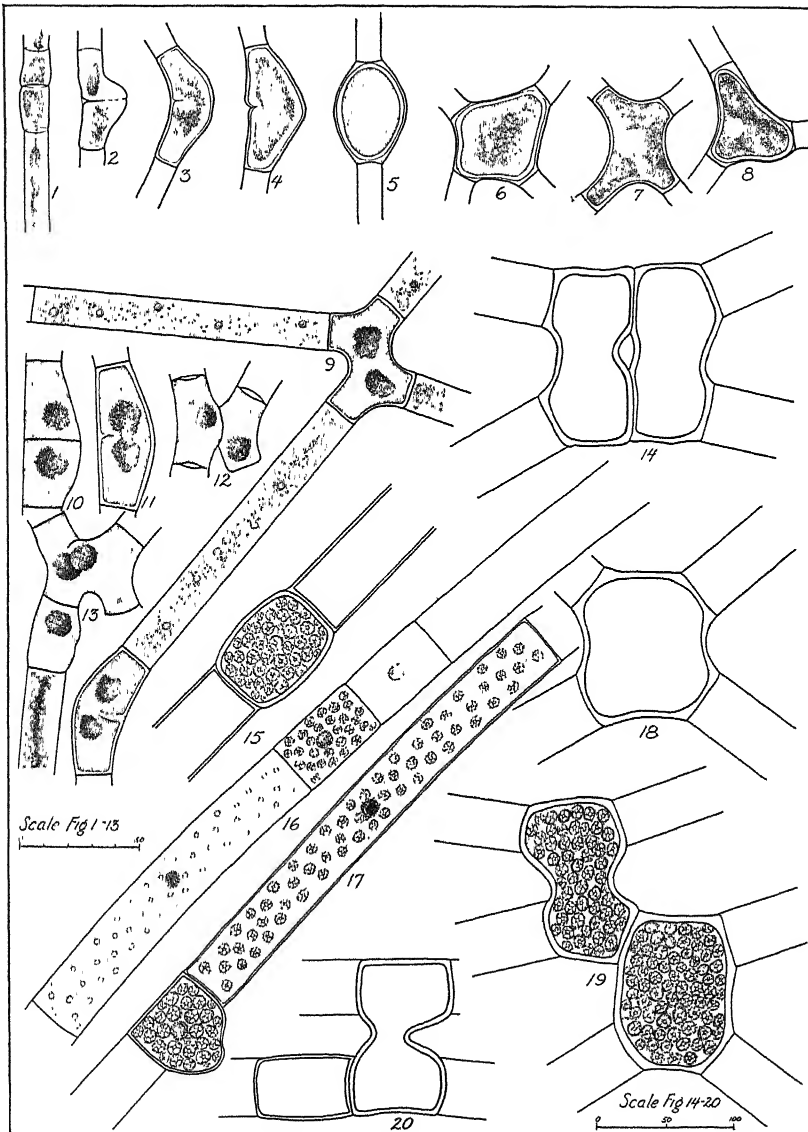
Fig. 14. *T. thaxteri.* Paired zygospores formed by scalariform conjugation of paired gametes.

Fig. 15. *T. thaxteri.* Aplanospore formed from a single gamete.

Fig. 16. *T. thaxteri.* Paired gametangia, each cut off from adjoining vegetative cells. Note increased number of pyrenoids, and their enlargement due to starch accumulation.

Fig. 17. *T. thaxteri.* Vegetative cell and parthenospore.

Figs. 18–20. *T. thaxteri.* Variations in form of zygospores. In Figure 19 the enlarged and crowded pyrenoids are shown. In Figure 20 a pair of gametes in two filaments have united, the unpaired gamete has formed an aplanospore.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OKLAHOMA ROTIFERS.

CLARENCE E. TAFT,
University of Oklahoma.

The repeated appearance of rotifers in the algal collections suggested the importance of a taxonomic study of the group within the state. It was found that upon intensive collecting and a study of existent algal collections, the rotifer fauna was abundant and widely distributed. These facts alone indicated the importance of such a group to the student of aquatic biology, or of still more vital interest to the teacher of aquatic biology, who comes into almost daily contact with its members.

As the literature, at present available for the study of rotifers is not abundant, and which is, moreover, widely scattered, the apparent need was for a summary of the common rotifers, including plates, by which a rapid and accurate identification would be possible.

This paper does not attempt to present a complete list of all the rotifers in the state, but it does offer a means for identification of some of the more common forms. Furthermore it is hoped it will stimulate an interest in the study of the group in other regions as well in the State of Oklahoma.

Most of the rotifers included belong to the loricate or semi-loricate groups due to the fact that identifications were made from preserved material, which the circumstances during collection made necessary. The illoricate forms, composing a minor group, such as those from the genera *Philodina*, *Rotifer*, and *Notommata*, are practically impossible to identify when dead, unless especially fixed and preserved. Such a process is rather impracticable in the field. The loricate and semi-loricate forms, due to their more or less hardened outer covering, may be identified without the aid of the delicate internal structures, by using only the shape and sculpturing of the lorica. In most cases the eye, or eyes, remain intact after death, thereby furnishing another valuable aid in identification.

Although the most intensive collecting was carried on in the central part of the state, many collections were secured from other regions. These were sufficient in number to warrant the list as being a representative one for the state.

I wish to express my appreciation to Dr. A. O. Weese, of the Zoology Department of the University of Oklahoma, for the advice and helpful criticism which he has given. I also wish to thank the members of the Botany and Zoology Departments of that University for the collections which they have made. To my wife, Celeste Whaley Taft, I extend my sincerest appreciation for assistance in collecting, identification of species, and proof reading.

Following is a list of the Genera identified. The second name, which in a number of cases follows the first, is the new generic name proposed by Harring in 1913.

1. *Philodina* Ehrenberg.
2. *Rotifer* Schrank.
   Rotaria (Scopoli) Harring, 1913.
3. *Melicerta* Schrank.
   Floscularia (Cuvier) Harring, 1913.
4. *Floscularia* Oken.
   Collotheca (Harring), *g. n.*, 1913.
5. *Apsilus* Metschnikoff.
   Cupelopagis (Forbes) Harring, 1913.
6. *Asplanchna* Gosse.
7. *Pedalion* Hudson.
   . *Pedalia* (Barrois) Harring, 1913.
8. *Triarthra* Ehrenberg.
   Filiana (Bory) Harring, 1913.
9. *Polyarthra* Ehrenberg.
10. *Microcodon* Ehrenberg.
11. *Copeus* Gosse.
12. *Notommata* Gosse (nec Ehr.).
13. *Proales* Gosse.
14. *Furcularia* Ehrenberg.
    Encentrum (Ehrenberg) Harring, 1913.
15. *Eosphora* Ehrenberg.
16. *Anuraea* Gosse (nec Ehr.).
    Keratella (Bory de St. Vincent) Harring, 1913.
17. *Notholca* Gosse.
18. *Eretmia* Gosse.
19. *Pterodina* Ehrenberg.
    Testudinella (Bory) Harring, 1913.
20. *Brachionus* Ehrenberg.
21. *Noteus* Ehrenberg.
    Platyias (Harring), *g. n.*, 1913.
22. *Stephanops* Ehrenberg.
    Squatinella (Bory) Harring, 1913.
23. *Mastigocerca* Ehrenberg.
24. *Rattulus* Ehrenberg.
    Trichocerca (Lamarck) Harring, 1913.
25. *Coelopus* Gosse.

26. *Salpina* Ehrenberg.
    Mytilina (Bory) Harring, 1913.
27. *Diaschiza* Gosse.
28. *Dinocharis* Ehrenberg.
    Trichotria (Bory) Harring, 1913.
29. *Scaridium* Ehrenberg.
30. *Euchlanis* Ehrenberg.
31. *Cathypna* Gosse.
    Lecane (Nitzsch) Harring, 1913.
32. *Distyla* Eckstein.
    Lecane (Nitzsch) Harring, 1913.
33. *Monostyla* Ehrenberg.
34. *Colurus* Ehrenberg.
35. *Metopidia* Ehrenberg.
    Lepodella (Bory) Harring, 1913.

An Artificial Key for the Determination of the Subclasses, Orders, Suborders, Families, and Genera, of the Class Rotifera.

Keys to the species have been purposely omitted from this paper in order to simplify identification. Keys not accompanied by diagrams are practically useless, and when present along with the diagrams tend to confuse the investigator, who in the end usually resorts to the drawings for the final identification. As only a few species were found in any one genus, and as these are all figured, it was felt that species keys were not essential.

1. Usually microscopic organisms of greatly varied sizes and outlines. In all cases having a ciliated area at the anterior end which varies extensively throughout the group. The body may be either soft (worm-like), or encased in a more or less distinctly stiffened cuticle (lorica). It usually extends posteriorly to some sort of a stalk or foot. The alimentary tract, when complete, has a pharynx with a pair of chitinous jaws and a dorsal cloacal opening near the foot. The excretory system consists of flame cells. In most cases there is a well developed nervous system with a distinct brain. Males of only a few species are known. When found they are smaller than the females, and are almost always degenerate.
   Class Rotifera.

2 (7). Females having two ovaries; no lorica.
   Subclass Digononta.

3 (8) (14). Body soft (worm-like); creeping worm-like, or swimming by means of the expanded corona; jaws ramate.
   Order Bdelloida.

4. Corona composed of two ciliated discs, projecting from the head on short broad stalks.
Family Philodinadae.

5 (6). Eyes two, located in the neck and over the brain.
Genus Philodina, spp. *roseola* (Fig. 1), *aculeata* (Fig. 2).

6 (5). Eyes two, located in the dorsal probosis.
Genus Rotifer, sp. *macrurus* (Fig. 3).

7 (2). Females having one ovary; with or without a definite lorica.
Subclass Monogononta.

8 (3) (14). Forms usually attached by means of a cup or disc at the end of the foot; generally tube builders; in free swimming forms the tube is transparent and is carried about with the organism.
Order Rhizota

9 (11). Individual or colonial.............................10

10. Corona not produced into greatly elongated lobes; lobes four, edged by groups of strong cilia which are unequal in length.
Family Melicertadae, Genus Melicerta, sp. *ringens* (Figs. 4 and 5).

11 (9). Never colonial.......................................12

12 (13). Corona usually produced into elongated lobes of varying number, lobes edged by long radiating setae.
Family Floscularadae, Genus Floscularia, spp. *campanulata* (Fig. 6, *sp.* (Fig. 7).

13 (12). Corona never lobed or produced, but composed of a large membraneous sac; foot a flat disc.
Family Apsilidae, Genus Apsilus, sp. *bucinedax* (Fig. 8).

14 (3) (8). Forms not permanently attached; never colonial, and without tubes; jaws never ramate.
Order Ploima.

15 (35). Illoricate forms, not having the body cuticle hardened to form a shell.
Suborder Illoricata.

16 (23). No foot present....................................17

17 (18). Body large, clear, no appendages; jaws incudate; viviparous; one eye.
Family Asphanchnadae, Genus Asplanchna, sp. *Brightwellii* (Fig. 9).

18 (17). Body varying in size, bearing movable spines, blades, or branching appendages.
Family Pedalionadae.

19 (20). Appendages branched, six in number; two eyes.
Genus Pedalion, sp. *mirum* (Fig. 11).

20 (19). Appendages not branched.
Family Triarthradae.

21 (22). Appendages three, very long, one ventral, and two lateral, ventral shorter than the lateral.
Genus Triarthra, sp. *longiseta* (Fig. 10).

22 (21). Appendages twelve, blade-shaped, with serrate margins, arranged in four groups of three each; one eye.
Genus Polyarthra, sp. *platyptera* (Fig. 12).

23 (16). Foot present..24

24 (25). Foot ending in one toe; mouth located in the center of a coronal ring of strong cilia; one eye.
Family Microcodontidae, Genus Microcodon, sp. *clavus* (Fig. 13).

25 (24). Foot ending in two toes; no body appendages; corona a densely ciliated oblique area without prominences; some forms with two lateral, ciliated, retractile auricles.
Family Notommatadae.

26 (33). Organisms with one eye..............................27

27 (32). Eye not located in the extreme anterior end of the body, but in the neck and attached to the brain............28

28 (29). Body large, not crenulate; corona usually extending onto a large, movable, ciliated "lip;" body projecting beyond the foot in a sac-like tail; toes large.
Genus Copeus, sp. *labiatus* (Fig. 14).

29 (28). Body small to medium size..........................30

30 (31). Auricles present; toes small; body often ending in a large tail.
Genus Notommata, sp. *aurita* (Fig. 15).

31 (30). Auricles never present; corona often an oblique ciliated surface, or even extending to the ventral surface; body small.
Genus Proales, sp. *petromyzon* (Fig. 16).

32 (27). Eye nearly always at the extreme anterior end of the body; body cylindrical, conical in front; two toes, large and conspicuous.
Genus Furcularia, sp. *forficula* (Figs. 17 and 18).

33 (26). Organisms with three eyes...........................34

34. One eye larger than the other two, and located posteriorly from them.
Genus Eosphora, sp. *digitata* (Fig. 19).

35 (15). Loicate forms, having the body cuticle hardened to form a shell.
Suborder Loricata.

36 (42). Foot absent.......................................37

37. Lorica usually six-toothed in front, with or without spines behind, both ends open.
Family Anuraeadae.

38 (41). Lorica oblong, or elongated oblong, dorsal surface convex, ventral surface plane..............................39

39 (40). Dorsal surface marked off into polygonal areas.

Genus Anuraea, spp. *aculeata* (Fig. 20), *serrulatus* (Fig. 21), *cochlearis*, var. *macrocantha* (Fig. 23).

40 (39). Dorsal surface without definite areas, but having longitudinal striations.

Genus Notholca, sp. *acuminata* (Fig. 22).

41 (38). Lorica sac-like; the anterior end open, narrower than the closed posterior end, serrate; posterior end with five or six lateral and terminal, long, sharp spines; surface of lorica divided into diamond-shaped areas.

Genus Eretmia, sp. *cubeutes* (Fig. 25).

42 (36). Foot present....................................43

43 (46). Foot transversely wrinkled, retractile..................44

44 (45). Foot ending in a ciliated cup; lorica thin, strongly flattened dorso-ventrally; corona a ciliary wreath of two lateral semi-circles; two eyes.

Family Pterodinadae, Genus Pterodina, sp. *patina* (Fig. 24).

45 (44). Foot ending in two small toes; lorica with dorsal, and sometimes ventral anterior spines; posterior spines may be present; lorica strongly convex above, flattened or slightly convex below. (In one species of the following genus, *militaris*, the foot is not transversely wrinkled, but is jointed.)

Family Brachionidae, Genus Brachionus, spp. *pala* (Fig. 27), *sp.* (Fig. 26), *rubens** (Fig. 28), *militaris* (Fig. 30), *angularis* var. *caudatus* (Fig. 29), *Mulleri* (Fig. 31).

46 (43). Foot not transversely wrinkled, not retractile...........47

47 (48). Lorica flattened; both anterior and posterior spines present; no eyes.

Genus Noteus, sp. *quadricornis* (Fig. 32).

48 (47). Lorica cylindrical, covering both dorsal and ventral surfaces; head covered by a broad almost circular, non-movable plate.

Genus Stephanops,† spp. *muticus* (Fig. 33), *sp.* (Fig. 35).

49 (57). Foot very short, with one, two, or more slender toes....50

50 (54). Lorica enclosed entirely around the body, ends open, cylindrical, fusiform, or ovate, usually asymmetrical; one eye.

Family Rattulidae.

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*Rousselet, Journ. Quekett Micros. Club, 1907, claims the specimen of Hudson and Gosse to be wrongly described and identified.

†The genus Stephanops is a very difficult genus to classify. It probably belongs more nearly in the Family Dinocharidae than in the Brachionidae, but because of several varying characteristics it seems to be more easily keyed under the latter. If the user of this key will kindly remember that it is purely an artificial one, it should cause no grave concern.

51(52)(53). Toes single, long and straight, sometimes with other short accessory toes.
Genus Mastigocerca, spp. *capucina* (Fig. 34), *macera* (Fig. 38), *rattus* (Fig. 37), *sp.* (Fig. 36).

52(51)(53). Toes two, equal, bristle-like, having a length of half, or less than half that of the body.
Genus Rattulus, spp. *tigris* (Fig. 39), *cylindricus* (Fig. 40).

53(51)(52). Toes two, unequal, bristle-like, the shorter being more than half the length of the longer; accessory toes may be present.
Genus Coelopus, sp. *tenuoir* (Fig. 41).

54 (50). Lorica not closed on a line down the middle of the dorsal surface, but having the two sides connected by a membrane; toes blade-shaped.
Family Salpinadae.

55 (56). Lorica a well developed box-like structure having the ends open, and with a distinct median dorsal cleft; both anterior and posterior ends with spines; one eye.
Genus Salpina, spp. *spinigera* (Fig. 42), *eustala* (Fig. 43).

56 (55). Lorica not well developed, median dorsal cleft indistinct, no spines; one eye.
Genus Diaschiza, spp. *hoodii* (Fig. 44), *semiaperta* (Fig. 45), *sp.* (Figs. 46 and 47).

57 (49). Foot long, usually of several joints......................58

58 (61). Lorica vase-shaped, entire; head with a chitinous cap.
Family Dinocharidae.

59 (60). Lorica thickened, faceted roughened; no spines; foot with two dorsal spines, foot and toes about as long or slightly longer than the body; one eye.
Genus Dinocharis, spp. *pocillum* (Fig. 48), *tetractis* (Fig. 49).

60 (59). Lorica thin, transparent, smooth; toes, foot, and body about the same length; eye on the mastax.
Genus Scaridium, sp. *longicaudum* (Fig. 50).

61 (58). Lorica not vase-shaped, but ranging from subcircular, circular, subovate, ovate, to elliptical in outline......62

62 (69). Lorica composed of two plates, located dorsally and ventrally...63

63 (64). Plates dissimilar, the dorsal one larger and strongly convex; body ending posteriorly in a jointed foot having two rather large blade-shaped toes.
Family Euchlanidae, Genus Euchlanis, spp. *deflexa* (Fig. 51), *uniseta* (Fig. 53), *macrura* (Fig. 52).

64 (63). Plates more nearly alike, separated by a deep lateral furrow having a flexible membrane; the body ending posteriorly in one or two rather large, rod-like toes; the foot is inconspicuous.
Family Cathypnadae.

65 (68). Two toes.......................................66

66 (67). Lorica ovate, oval, to subcircular; lateral cleft deep.
Genus Cathypna, spp. *luna* (Fig. 54), *leontina* (Fig. 55).

67 (66). Lorica elongate-ovate, slightly extended behind, lateral cleft indistinct.
Genus Distyla, spp. *ohioensis* (Fig. 56), *gissensis* (Fig. 57), *sp.* (Fig. 58).

68 (65). One toe.
Genus Monostyla, spp. *quadridentata* (Fig. 59), *lunaris* (Fig. 60), *Bulla* (Fig. 61), *sp.* (Fig. 62).

69 (62). Lorica composed of a single plate, which may be slightly compressed laterally, or dorso-ventrally flattened; the head is covered by an over-hanging chitinous shield.
Family Coluridae.

70 (71). Lorica slightly compressed laterally, arched dorsally, open at the ends, sometimes open ventrally.
Genus Colurus, spp. *grallator* (Fig. 63), *bicuspidatus* (Fig. 64).

71 (70). Lorica not laterally compressed, the surface with definite sculptured areas, and with a mid-dorsal and a mid-ventral ridge extending backward from the anterior end about to the mid-point of the body.
Genus Metopidia, spp. *Ehrenbergii* (Figs. 65 and 66), *oxysternon* (Figs. 67 and 68), *solidus* (Fig. 69).

A list of the species figured in this paper follows, along with their habitat and general distribution in the state. As previously stated, many of them bear two names, due to the fact that Harring in 1913 changed the generic names of a number of forms, and gave in defense of this change the rule of priority of nomenclature. Because most of the literature available describes the species under the old name it was thought best to include both names in the present paper.

1. *Philodina roseola* Ehrenberg. ....Fig. 1
Cosmopolitan in locality and habitat.
Length, .31 mm.

2. *Philodina aculeata* Ehrenberg ....Fig. 2
Cosmopolitan in locality and habitat.
Length, .66 mm.

3. *Rotifer macrurus* Schrank. ....Fig. 3
Rotaria macrurus (Schrank) Harring, 1913.
Shawnee Lake; quiet, weedy ponds.
Length, .3 mm.

4. *Melicerta ringens* Schrank ....Figs. 4, 5
Floscularia ringens (Schrank) Harring, 1913.
Shawnee Lake; quiet, weedy ponds.
Length, .64 mm.

5. *Floscularia companulata* Dobie. . . . . Fig. 6
Collotheca companulata (Dobie) Harring, *g. n.* 1913.
Horseshoe Lake; stagnating pond.
Length, .2 mm.

6. *Floscularia sp*. . . . . Fig. 7
Collotheca sp. Harring, *g. n.* 1913.
Canadian River Oxbow; quiet, muddy water.
Length, .49 mm.

7. *Apsilus bucinedax* Forbes. . . . . Fig. 8
Cupelopagis bucinedax (Forbes) Harring, 1913.
Indian Springs; clear, running water.
Length, 1.77 mm.

8. *Asplanchna brightwellii* Gosse . . . . Fig. 9
Lake Overholser; plankton.
Length, 1 mm.

9. *Triarthra longiseta* Ehrenberg. . . . . Fig. 10
Filinia longiseta (Ehrenberg) Harring, 1913.
Lake Overholser; plankton.
Length, .9 mm.

10. *Pedalion mirum* Hudson. . . . . Fig. 11
Pedalia mirum (Hudson) Harring, 1913.
Lake Overholser; plankton.
Length, .21 mm.

11. *Polyarthra platyptera* Ehrenberg . . . . Fig. 12
Lake Overholser; plankton.
Length, .15 mm.

12. *Microcodon clavus* Ehrenberg . . . . Fig. 13
Shawnee Lake; quiet, weedy ponds.
Length, .25 mm.

13. *Copeus labiatus* Gosse . . . . Fig. 14
Indian Springs; clear, quiet water.
Length, .9 mm.

14. *Notommata aurita* Ehrenberg. . . . . Fig. 15
Indian Springs; clear, quiet water.
Length, .27 mm.

15. *Proales petromyzon* Ehrenberg . . . . Fig. 16
Indian Springs; clear, running water.
Length, .15 mm.

16. *Furcularia forficula* Ehrenberg. . . . . Figs. 17, 18
Encentrum forficula (Ehrenberg) Harring, 1913.
Indian Springs; clear, quiet water.
Length, .15 mm.

17. *Eosphora digitata* Ehrenberg. . . . . Fig. 19
Horseshoe Lake; weedy, semi-stagnant water.
Length, .75 mm.

18. *Anuraea aculeata* Ehrenberg. . . . . Fig. 20
Keratella aculeata (Ehrenberg) Harring, 1913.
Lake Overholser; plankton.
Length, .18 mm.

19. *Anuraea serrulatus* Ehrenberg. . . . . Fig. 21
Keratella serrulatus (Ehrenberg) Harring, 1913.
Meeker; grass grown cattle tank.
Length, .11 mm.

20. *Anuraea cochlearis* Gosse var. *macrocantha* Gosse. . . . . Fig. 23
Keratella cochlearis (Gosse) var. *macrocantha* (Gosse) Harring, 1913.
Horseshoe Lake; quiet, weedy water.
Length, .13 mm.

21. *Notholca acuminata* Ehrenberg. . . . . Fig. 22
Edmond; clear, running water.
Length, .27 mm.

22. *Pterodina patina* Ehrenberg .... Fig. 24
Testudinella patina (Ehrenberg) Harring, 1913.
Arbuckle Mts., Canadian River Ox-bow, Shawnee Lake; cosmopolitan.
Length, .17 mm.

23. *Eretmia cubeutes* Gosse... .... Fig. 25
Indian Springs; clear, quiet water.
Length, .06 mm.

24. *Brachionus* sp.. . . .. Fig 26
Lake Overholser; plankton.
Length, .3 mm.

25. *Brachionus pala* Ehrenberg..... . Fig. 27
Horseshoe Lake; plankton.
Length, .32 mm.

26. *Brachionus rubens* Ehrenberg. .... .Fig. 28
Canadian River Ox-bow; muddy, standing water.
Length, .24 mm.

27. *Brachionus angularis* Gosse var. *caudatus* Dad .. . .Fig. 29
Lake Overholser; plankton.
Length, .25 mm.

28. *Brachionus militaris* Ehrenberg. . . .. Fig. 30
Ten Mile Flats; weedy, stagnant pond.
Length, .18 mm.

29. *Brachionus Mulleri* Ehrenberg. .. .. .Fig. 31
Great Salt Plains; very brackish water.
Length, .24 mm.

30. *Noteus quadracornis* Ehrenberg . ... Fig. 32
Platyias quadracornis (Ehrenberg) Harring, 1913.
Wichita Mts.; weedy, standing pond.
Length, .26 mm.

31. *Stephanops muticus* Ehrenberg ... . Fig. 33
Squatinella muticus (Ehrenberg) Harring, 1913.
Shawnee Lake; weedy, standing pond.
Length, .26 mm.

32. *Stephanops sp*........ .. .. Fig. 35
Squatinella sp. Harring, 1913.
Horseshoe Lake; stagnant water.
Length, .21 mm.

33. *Mastigocerca capucina* Wierz. and Zach. ....Fig. 34
Horseshoe Lake; plankton.
Length, .12 mm.

34. *Mastigocerca sp*............ . .. .Fig. 36
Shawnee Lake; quiet, weedy water.
Length, .2 mm.

35. *Mastigocerca rattus* Ehrenberg .... .Fig. 37
Indian Springs; clear, quiet water.
Length, .34 mm.

36. *Mastigocerca macera* Gosse. .... .Fig. 38
Indian Springs; quiet, clear water.
Length, .2 mm.

37. *Rattulus tigris* Muller ....Fig. 39
Trichocerca tigris (Muller) Harring, 1913.
Indian Springs; quiet, clear water.
Length, .19 mm.

38. *Rattulus cylindricus* Imhof......... ....Fig. 40
Trichocerca cylindricus (Imhof) Harring, 1913.
Indian Springs; Horseshoe Lake; quiet, clear water.
Length, .28 mm.

39. *Coelopus tenuoir* Gosse . .. .Fig. 41
Indian Springs; quiet, clear water.
Length, .28 mm.

40. *Salpina spinigera* Ehrenberg.............................. ....Fig. 42
Mytilina spinigera (Ehrenberg) Harring, 1913.
Indian Springs; quiet, clear water.
Length, .23 mm.

41. *Salpina eustala* Gosse............ ....Fig. 43
Mytilina eustala (Gosse) Harring, 1913.
Indian Springs; quiet, clear water.
Length, .32 mm.

42. *Diaschiza hoodi* Gosse...................................... ....Fig. 44
Indian Springs; Horseshoe Lake; stagnant water.
Length, .23 mm.

43. *Diaschiza semiaperta* Gosse............... ... . Fig. 45
Indian Springs; stagnant water.
Length, .27 mm.

44. *Diaschiza sp.* .... Figs 46, 47
Shawnee Lake; weedy ponds.
Length, .14 mm.

45. *Dinocharis pocillum* Ehrenberg.... .... Fig. 48
Trichotria pocillum (Ehrenberg) Harring, 1913.
Indian Springs; clear, standing pond.
Length, .32 mm.

46. *Dinocharis tetractis* Ehrenberg ....Fig. 49
Trichotria tetractis (Ehrenberg) Harring, 1913.
Indian Springs; quiet, clear water.
Length, .33 mm.

47. *Scaridium longicaudum* Ehrenberg.... ....Fig. 50
Indian Springs; Horseshoe Lake; quiet, clear water.
Length, .39 mm.

48. *Euchlanis deflexa* Gosse........ . ...Fig. 51
Ten Mile Flats; stagnant pond.
Length, .29 mm.

49. *Euchlanis macrura* Ehrenberg..... .. ..Fig. 52
Indian Springs; quiet, clear pool.
Length, .27 mm.

50. *Euchlanis uniseta* Leydig................. . ... Fig. 53
Indian Springs; quiet, clear pool.
Length, 1.45 mm.

51. *Cathypna luna* Ehrenberg.................. .. ..Fig. 54
Lecane luna (Ehrenberg) Harring, 1913.
Indian Springs; quiet, clear water.
Length, .19 mm.

52. *Cathypna leontina* Turner.................... . . ..Fig. 55
Lecane leontina (Turner) Harring, 1913.
Ten Mile Flats; stagnant pool.
Length, .36 mm.

53. *Distyla ohioensis* Herrick...Fig. 56
Lecane ohioensis (Herrick) Harring, 1913.
Wichita Mts.; rock pools.
Length, .1 mm.

54. *Distyla gissensis* Eckstein................. ....Fig. 57
Lecane gissensis (Eckstein) Harring, 1913.
Horseshoe Lake; quiet, clear pool.
Length, .09 mm.

55. *Distyla sp.* .. ..Fig. 58
Lecane sp. Harring, 1913.
Ten Mile Flats; stagnant pond.
Length, .13 mm.

56. *Monostyla quadridentata* Ehrenberg.................. .... .Fig. 59
Horseshoe Lake; Ten Mile Flats; stagnant water.
Length, .28 mm.

57. *Monostyla lunaris* Ehrenberg. . . .. Fig. 60
Horseshoe Lake; quiet, clear water.
Length, .12 mm.

58. *Monostyla bulla* Gosse . . . . Fig. 61
Horseshoe Lake; stagnant water.
Length, .25 mm.

59. *Monostyla sp.* .. .. Fig. 62
Indian Springs; quiet, clear water.
Length, .13 mm.

60. *Colurus grallator* Gosse . . . . Fig. 63
Indian Springs, Horseshoe Lake; clear, standing water.
Length, .12 mm.

61. *Colurus bicuspidatus* Ehrenberg . . .. Fig. 64
Shawnee Lake; quiet, weedy pond.
Length, .13 mm.

62. *Metopidia ehrenbergii* Perty ... ... Figs. 65, 66
Lepodella ehrenbergii (Perty) Harring, 1913.
Horseshoe Lake; quiet, weedy pond.
Length, .14 mm.

63. *Metopidia oxysternon* Gosse... . . .. Figs. 67, 68
Lepodella oxysternon (Gosse) Harring, 1913.
Shawnee Lake, Horseshoe Lake, Indian Springs; weedy, standing ponds and clear pools.
Length, .11 mm.

64. *Metopidia solidus* Gosse. . . .. Fig. 69
Lepodella solidus (Gosse) Harring, 1913.
Indian Springs, Horseshoe Lake, Wichita Mts.; cosmopolitan.
Length, .13 mm.

LITERATURE CITED.

1. **Gosse, P. H.** 1887. Twenty-four New Species of Rotifera. Journ. Roy. Mic. Soc., pp. 1–7.
1887. Twelve New Species of Rotifera. Jour. Roy. Mic. Soc., pp. 361–367.
2. **Herrick, C. L.** 1895. Notes on American Rotifers. Bull. of the Scientific Lab. of Denison University. V., pp. 44–62.
3. **Hudson, C. T., and Gosse, P. H.** 1889. The Rotifera or Wheel Animalcules. 2 vol. London.
4. **Jennings, H. S.** 1894. The Rotatoria of the Great Lakes and some of the Inland Lakes of Michigan. Bull. Mich. Comm., No. 3, pp. 361–367.
1899. Rotatoria of the United States U. S. Fish Comm. Bull., pp. 67–104.
1901. Synopsis of North American Invertebrates. XVII. The Rotatoria. Am. Nat., 35: 725–777.
5. **Murray, J.** 1913. Notes on the Family Cathypnidae. Journ. Roy. Mic. Soc., pp. 341–362, 451–461, 545–564.
6. **Rousselet, C. F.** 1907. New Rotifera. Journ. Quekett Mic. Club, pp. 147–154.
1916. Fifth List of New Rotifers since 1889. Jour. Roy. Mic. Soc., pp. 19–28.
7. **Ward, H. B., Whipple, G. C.** 1918. Fresh-water Biology, pp. 553–620.

EXPLANATION OF PLATES.

PLATE I.

1. *Philodina roseola* Ehr .... × 125
2. *Philodina aculeata* Ehr........ × 63
3. *Rotifer macrurus* Schrank........ × 125
4. *Melicerta ringens* Schrank, head .... × 100
5. Same, head projecting from tube........ × 33
6. *Floscularia companulata* Dobie........ × 167
7. *Floscularia* sp .... × 100
8. *Apsilus bucinedax* Forbes........ × 100
9. *Asplanchna Brightwellii* Gosse........ × 100
10. *Triarthra longiseta* Ehr........ × 167
11. *Pedalion mirum* Hudson........ × 125
12. *Polyarthra platyptera* Ehr........ × 100

PLATE II.

13. *Microcodon clavus* Ehr........ × 100
14. *Copeus labiatus* Gosse .... × 33
15. *Notommata aurita* Ehr. (from Ward and Whipple) after Weber........ × 100
16. *Proales petromyzon* Ehr .... × 167
17. *Furcularia forficula* Ehr .... × 167
18. Same, toes greatly enlarged.
19. *Eosphora digitata* Ehr .... × 125
20. *Anuraea aculeata* Ehr .... × 125
21. *Anuraea serrulatus* Ehr........ × 167
22. *Notholca acuminata* Ehr........ × 125
23. *Anuraea cochlearis* var. *macrocantha* Gosse........ × 167
24. *Pterodina patina* Ehr .... × 125
25. *Eretmia cubentes* Gosse .... × 167
26. *Brachionus* sp .... × 125
27. *Brachionus pala* Ehr .... × 125

PLATE III.

28. *Brachionus rubens* Ehr........ × 125
29. *Brachionus angularis* var. *caudatus* Dad........ × 125
30. *Brachionus militaris* Ehr........ × 125
31. *Brachionus Mulleri* Ehr........ × 125
32. *Noteus quadracornis* Ehr........ × 125
33. *Stephanops muticus* Ehr........ × 167
34. *Mastigocerca capucina* Wierz. and Zach........ × 167
35. *Stephanops* sp........ × 167
36. *Mastigocerca* sp........ × 167
37. *Mastigocerca rattus* Ehr .... × 125
38. *Mastigocerca macera* Gosse........ × 167
39. *Rattulus tigris* Muller........ × 167
40. *Rattulus cylindricus* Imhof........ × 167

PLATE IV.

41. *Coelopus tenuoir* Gosse........ × 167
42. *Salpina spinigera* Ehr........ × 125
43. *Salpina eustala* Gosse........ × 100
44. *Diaschiza hoodi* Gosse .... × 125
45. *Diaschiza semiperta* Gosse .... × 125
46. *Diaschiza* sp., side view .... × 167
47. Same, dorsal view........ × 167
48. *Dinocharis pocillum* Ehr........ × 125
49. *Dinocharis tetractis* Ehr. (from Hudson and Gosse)........ × 125
50. *Scaridium longicaudum* Ehr........ × 125
51. *Euchlanis deflexa* Gosse........ × 125
52. *Euchlanis macrura* Ehr. (from Ward and Whipple) after Weber .... × 125

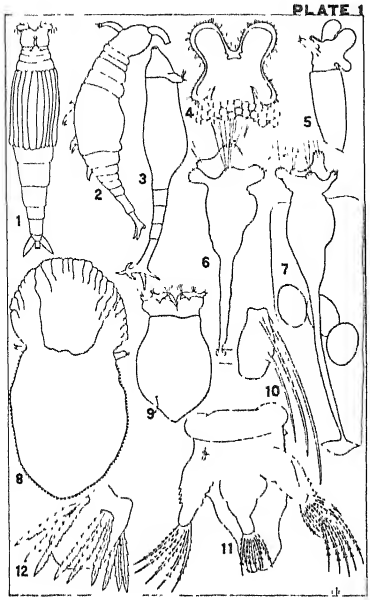
PLATE 1
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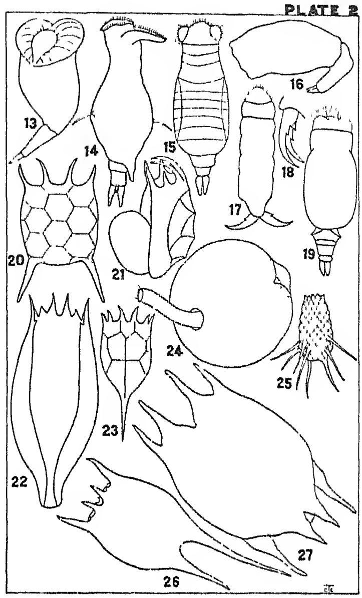
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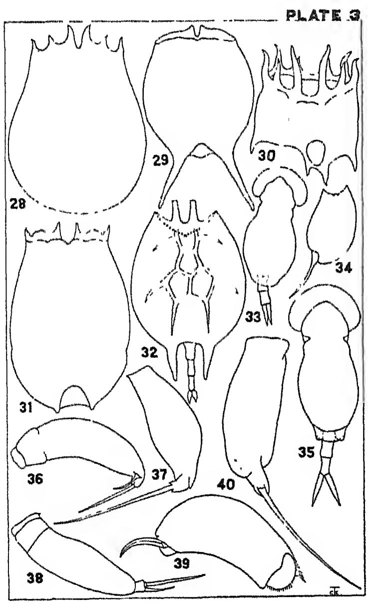
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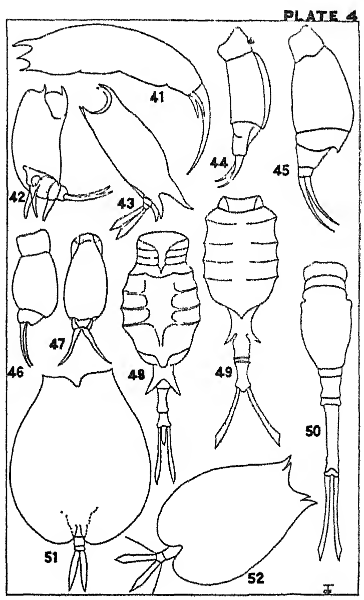
PLATE 4
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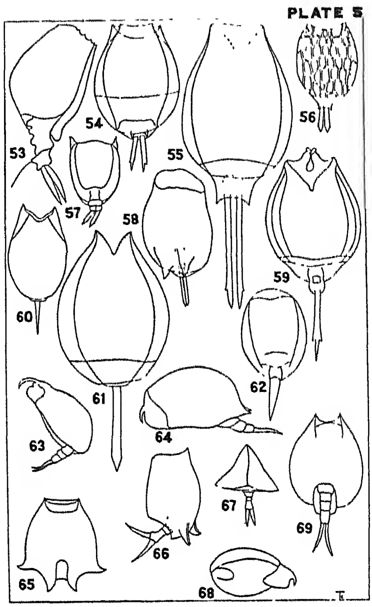

PLATE V.

53. *Euchlanis uniseta* Leydig... ×100
54. *Cathypna luna* Ehr ... ×125
55. *Cathypna leontina* Turner... ×125
56. *Distyla ohioensis* Herrick... ×167
57. *Distyla gissensis* Eckstein... ×167
58. *Distyla* sp... ×167
59. *Monostyla quadridentata* Ehr... ×125
60. *Monostyla lunaris* Ehr ... ×167
61. *Monostyla Bulla* Gosse... ×167
62. *Monostyla* sp... ×167
63. *Colurus grallator* Gosse... ×167
64. *Colurus bicuspidatus* Ehr... ×167
65. *Metopidia ehrenbergii* Perty, ventral view... ×167
66. Same, side view... ×167
67. *Metopidia oxysternon* Gosse, rear view... ×167
68. Same, ventral view... ×167
69. *Metopidia solidus* Gosse... ×167

THE SUBEPIDERMAL NERVE PLEXUS AND GALVANOTROPISM OF THE EARTHWORM. (LUMBRICUS TERRESTRIS LINN.)

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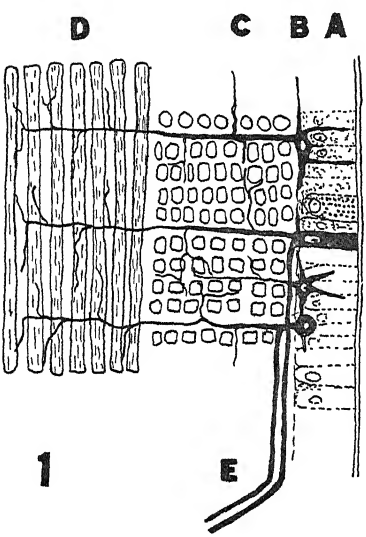
It is well known that the earthworm *Lumbricus terrestris* Linn. orients toward the cathode pole of direct electric current when the current is applied across a worm which is in water or on a moist surface. Moore and Kellogg (1916) explain this response as follows: "The constant current produces the effect described by increasing the tension of the longitudinal muscles on the cathode side of the worm, which results in this part being more strongly contracted than the anodal region." This is obviously a correct statement of the results, but it does not explain how these muscles at right angles to the direction of the current are made to contract on one side and not on the other.

Hyman and Bellamy (1923) in attempting to explain the same reaction say, "When Annelids are placed in a current the animals direct those parts positively charged internally toward the cathode and those parts negatively charged internally toward the anode." They do not explain, however, how a worm with a positive charge on the inside and a negative charge on the outside is made to bend toward the cathode. The reader is left to assume that there is an attraction between the negative charges of the cathode and the positive charges of the interior of the worm and vice versa.

Since the publications of the above in 1916 and 1923, respectively, Hess (1925) has described a subepidermal nerve plexus of the earthworm which might conceivably have some connection with the galvanotropic response. He has published a drawing of the subepidermal nerve plexus and the two sets of associated muscles. We have produced diagrammatically below (Figure 1) a similar drawing which shows the relations of the sensory cells to the muscles and to the central nervous system. This drawing, which is partly hypothetical, should be compared with Figures 6 and 7 of Hess (1925, p. 251 and p. 255).

To test the possible connection of the two, i. e., the subepidermal nerve plexus and the galvanotropic response, was the object of this investigation. The reasoning which led to the experiments to be described was as follows:

According to Lillie (1923, p. 276), "The stimulating action of a current is characteristically polar; i. e., the current produces its primary physiological effects chiefly at its regions of entrance and exit, and the effects at the two regions are typically opposite



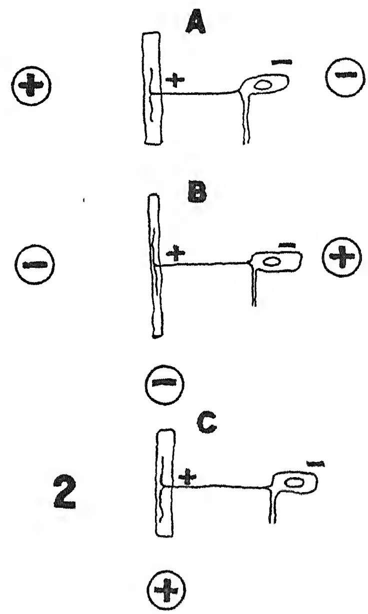


FIG. 1. Diagram illustrating the probable relation of the sensory cells in the lateral body wall to the circular and longitudinal muscles. A, epithelial layer; B, subepidermal nerve cells; C, circular muscle layer; D, longitudinal muscle layer; E, sensory nerve fibers (cut) to the nerve cord.

FIG. 2. Diagram illustrating the arrangement of electrodes in relation to the subepidermal cells and muscles. The electrodes are shown inside circles. A, the current direction, which causes longitudinal muscle contraction; B, the current direction which causes longitudinal muscle relaxation; C, the current direction which stimulates the muscles directly causing contraction.

or antagonistic. Typically, when the current is made, it initiates excitation at the cathode, (i. e., where the positive stream of the stimulating circuit passes from the tissue to the applied electrode), and inhibits activity (at the same time depressing irritability) at the anode." The above statement of Lillie is the usual form of the "Law of Polar Stimulation."

From the above it should then follow that a negative pole applied to the skin surface of an earthworm and a positive pole applied on the opposite (muscle) side should result in the stimulation of the subepidermal neurons and contraction of the circular and longitudinal muscles, provided that all traces of the ventral cord are removed. The reverse arrangement, i. e., the positive pole on the skin side and the negative pole on the muscle side should inhibit the stimulation of the neurons and relax the circular and longitudinal muscles. (See Figure 2.)

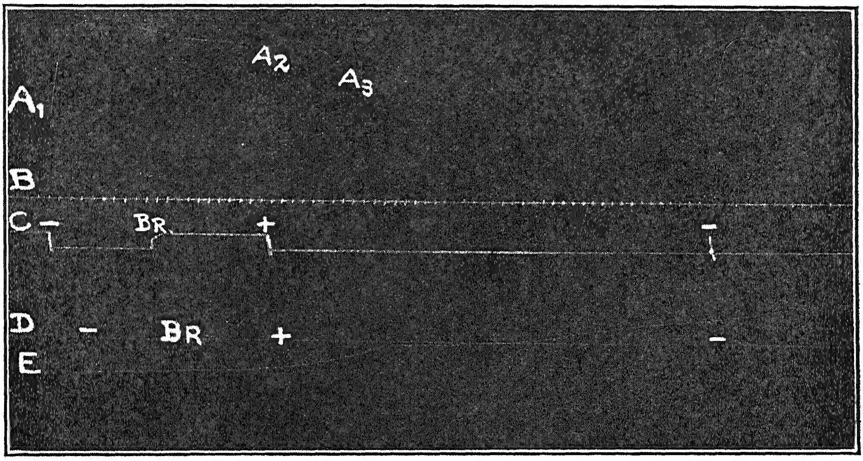


FIG. 3. Kymograph tracings which show the muscle responses under different conditions. A_1, A_2, A_3, tracing of muscle lever. The upward curve indicates contraction of the longitudinal muscles; B, time scale in seconds; C, tracing of magnet lever showing current and direction of current; D, tracing of muscle lever using narcotized tissue and direction of current; E, tracing of narcotized muscle when the current is passed lengthwise through the muscle.

APPARATUS AND METHODS.

From an earthworm that has been previously cooled in ice water a strip of lateral body wall about one and a half inches long and a quarter of an inch wide was removed. This was examined to be sure that it contained no trace of the ventral nerve cord. One end of the muscle was attached to a lever with a writing point and the other end to the bottom of a wax-lined dissecting dish. The writing point was placed against a smoked paper on a kymograph drum. Below this point was arranged a time lever and a lever connected to the reversible switch. (Figure 3, B and C.) On each side of the living strip

of body wall was placed a screen wire electrode so arranged that one electrode was parallel to the skin side and another was parallel to the muscle side. By means of a reversible switch the screen electrodes could be charged as desired. The current being derived from five dry batteries in series. Ice water was used as a conducting medium between the electrodes and the living strip of tissue. As soon as the current was made across the strip of tissue the lever registered the break or make of the current and the living strip either contracted or relaxed, making the records on the drum.

EXPERIMENTS.

Experiment 1.

In this experiment the electrodes were so arranged that the negative was on the skin side and the positive on the muscle side. The current was made registering on the drum (C—), at the same time the lever attached to the strip of tissue also registered at (A_1) showing a sudden contraction of the strip. Time is recorded in seconds at (B).

The result of the make of the current as described before is a contraction of the muscles as is shown on the graph. The current was kept going for nine and one-half seconds. The contraction of the muscle is shown by the rise of the line at (A_1). The current was then broken at the point marked Br. on the line (C). The lever attached to the tissue showed the gradual relaxation of the tissue for eleven seconds. Then the current was reversed at the point marked + on line C on the graph. The plus sign indicating that the positive electrode was at the skin side. Immediately the lever attached to the tissue showed a slight contraction at A_2 followed by a sudden relaxation. The current was kept on for forty-four seconds, thereby gradually lowering the curve (A_3) almost to the base line. Then the current was reversed again at the point marked — on curve (C) on the graph. Again the same result was registered as at (A_1).

Experiment 2.

The same strip of tissue is now allowed to soak in a very dilute solution of nicotine for four minutes. It is then taken out and attached again as in Experiment 1. The current is made at point marked — on curve (D). The current is kept on for eight seconds. The current is then broken at the point

marked Br. on curve (D) and the circuit is kept open for eight seconds. Then the current is on in reversed direction at the point marked + on the curve (D) and is kept that way for one minute. In this experiment one will notice that the curve made by the lever attached to the tissue line D was a straight line; indicating that the current had no effect whatsoever on the muscle tissue, which in the previous experiment gave clear cut results.

Experiment 3.

To the two ends of this same strip of tissue are now attached two wires in such a way that the same current can be sent through the muscle parallel to the direction of the fibres. The curve made by the lever attached to the muscle tissue in this case is the last one on the graph (E). The current was kept on for a minute and a half. The curve made by the lever in this case goes completely over the curve (D) made when the tissue was stimulated at right angles to the surface of the tissue (Experiment 2).

The results of experiments 1, 2, and 3 as detailed above are typical of five series which were carried out.

DISCUSSION OF RESULTS.

It was shown in Experiment 1 that the muscles contracted when the current was so arranged that the negative electrode was on the skin side and the positive electrode was on the muscle side, and that the muscles relaxed when the polarity of the current was reversed. Experiment 2 demonstrated the fact that when the strip of tissue which was treated with nicotine (thereby eliminating all nervous action) was at right angles to the current there was no reaction at all to the current. Experiment 3 showed that the muscles were still alive, since, when the current was run through the tissue lengthwise the muscles contracted.

This sequence of events shows by elimination that the contraction of the muscles in Experiment 1 was due to the stimulation of the subepidermal neurons and that these neurons were polarized in such a way that a reversal of the current caused not only a cessation of muscle stimulation but an active relaxation or loss of tone.

From the above it is quite clear that the neurons of the subepidermal nerve plexus control the longitudinal muscles

of the body wall of the earthworm directly and that they are electrically polarized at right angles to the surface.

The usual electrotactic response of a worm which is immersed in water can now be explained on a cause and effect basis. The longitudinal muscles on the side toward the cathode are stimulated because the polarity of the motor cells in the subepidermal nerve plexus is increased. At the same time the muscles on the side toward the anode are relaxed because the normal polarity of the motor nerve cells is decreased or possibly reversed. The two processes acting at the same time on opposite sides of the worm cause the worm to bend toward the cathode.

We are making no mention at this time of the fact that a normal worm crawls toward the cathode. The mechanism which controls this crawling is more complicated and evidently is not in any large way due to the action of the subepidermal nerve plexus.

BIBLIOGRAPHY.

1916. **Moore and Kellogg.** Biolog. Bulletin, Vol. 30, pp. 129-132.
1923. **Lillie, R. S.** Protoplasmic Action and Nervous Action. University of Chicago Press, pp. 1-417.
1923. **Hyman and Bellamy.** Biol. Bull., Vol. 43, pp. 340-343.
1925. **Hess, W. N.** Jour. Morph. and Physiol., Vol. 40, No. 2, pp. 235-259.

The Broad Field of Zoology.

This introductory zoology text is somewhat unique in that it is based on the author's belief that students should approach their study of zoology from the things with which they are familiar, and thus proceed to the aspects which are less familiar to them. With this very commendable basis, the book is built around the rat as an example of the mammals. System by system the rat is studied, with each chapter broadening out at the end into a discussion of that system in the vertebrates in general. Following reproduction are taken up embryology and heredity; following the skeletal system, locomotion; following the nervous system, animal behavior, etc. The book ends with a section on philosophical zoology, including distributional zoology, paleontology, and evolution. The impression given by the book is one of clear, well-rounded, authentic subject-matter, uniquely and practically arranged. Numerous original illustrations add considerably to the text. This book is intended as a companion volume in the elementary course to the author's earlier volume on Economic Zoology.—L. H. S.

An Introduction to Zoology, by Z. P. Metcalf. xix + 425 pp. Springfield, Ill., Charles C. Thomas, 1932.

SUPPLEMENTAL RECORDS AND NOTES ON OHIO LEAFHOPPERS.

HERBERT OSBORN,
Ohio State University.

During the two years that have elapsed since the publication of the "Leafhoppers of Ohio," with two seasons of good collecting and the assistance of Mr. E. P. Breakey, there have come to notice a number of species not entered as known to the Ohio fauna at the time of the printing of that Bulletin. Some of the species are those confidently predicted as belonging to our fauna and their collection anticipated. Some, however, were heretofore known from distant localities and their occurrence in Ohio not deemed as very probable. More detailed note of these will be given with the specific records.

This opportunity will be taken to revise certain changes in nomenclature and to correct a few errors in the bulletin which have come to notice since its printing.

Some of the additions noted serve to emphasize particularly the fact that distribution records for these insects, as indeed for many others, depend not only on intensive collecting at the proper season but especial reference to the varied hostplants and ecological habitats that support the various species.

Agallia oculata Van D. Previously recorded from Little Mt. only. This species was taken at Williams County by Mr. Breakey.

Macropsis rufocephalus, n. n. for *M. scutellatus* Osb., which name is preoccupied by the European *scutellatus* Boh. Delaware Co., June 10, 1932; Indian Lake, July 3, 1932.

Macropsis reversalis O. & B. (p. 215). Westerville, Franklin Co. (E. P. B.)

Macropsis basalis Van D. (p. 216). Westerville, Hudson, Westerville. (E. P. B.)

Macropsis trivialis Ball. Ashtabula Co., Columbus, Indian Lake.

Macropsis ferruginoides Van D. (p. 216). Westerville. (E. P. B.)

Macropsis erythrocephalus G. & B. (p. 216). Indian Lake and Rock Creek. (E. P. B.)

Macropsis sordidus Van D. (p. 217). Rock Creek, Ashtabula Co. (E. P. B.)

Macropsis nigricans Van D. (p. 217). Westerville, Franklin Co. (E. P. B.)

Macropsis bicolor Osb. Ashtabula Co. Heretofore known only from Maine.

Macropsis suturalis O. & B. Rock Creek, Ashtabula Co., June 24, 1931.

Macropsis tristis Van D.—Nymphs (p. 217). Rock Creek, Ashtabula Co., June 24, 1931, 2 P. M.

Macropsis insignis Van D. Ashtabula Co.

Macropsis osborni Breakey (Ms.)* Descriptions from Ohio specimens taken at Arcanum. (O. H. S.)

Macropsis cinerea Breakey, (Ms.).† Descriptions from Ohio specimen taken at Indian Lake. (E. P. B.)

Xerophloea majesta Lawson. Clermont Co., 9-15, J. M. Robinson. Similar to *major* Baker in the broad head.

Acocephalus flavostriatus Columbus (M. V. Anthony). Previously recorded for New York.

Xestocephalus coronatus O. & B. One specimen, Nettles Lake, Williams Co. (E. P. B.) This handsome little species was described from a specimen taken in Iowa and this Ohio specimen is the only other record that I know.

Xestocephalus brunneus Van D. Additional records are Columbus, Williams Co , Ashtabula Co., on Black Locust. (E. P. B.)

Scaphoideus melanotus Osb. Holgate, Logan Co., July 14, 1931. (Anthony).

Platymetopius cuprescens Osb. Adams Co., August 31, 1931. (H. O.) Previous records are for localities east of the Allegheny Mountains. Mr. Breakey took specimens of this species at Dune Park, Indiana, which carries the distribution still farther west.

Eutettix southwicki Van D. (p. 300). Brown Fruit Farm, Delaware Co.

Eutettix lurida Van D. Williams Co. (E. P. B.)

Novellina helenae Ball, Columbus—similar to *chenopodii* Osb., but smaller and with different picture.

Stirellus obtutus Van D. Rockbridge, Hocking Co., October 2, 1931. (H. O.) Taken at the E. S. Thomas shack.

Phlepsius incisus Van D. (p. 311). Brown Fruit Farm, near Worthington, August 15, 1931. (E. P. B.)

Phlepsius pusillus Baker (*collinus* O. & L.) Adams Co. (H. O.)

Phlepsius punctiscriptus Van D. Lynx and Hachelshin Ridge, Adams Co. (H. O.) Hocking Co. (E. P. B.)

Phlepsius majestus O. & B. Near London, Madison Co. (H. O.) September 7, 1931, Hocking Co. (E. P. B.) and, at light, Silver Lake, Bellefontaine, Logan Co., by D. J. Borror. Previous records for Columbus only.

Thamnotettix collaris Ball (p. 321). Taken at the Urbana bog, Champaign Co.

Paracoelidea tuberculata Baker. Rockbridge, Hocking Co. (E. S. Thomas shack), October 2, 1931. (E. P. B.) Previous records are from pine at points east of Appalachian divide.

Empoasca erigeron DeLong. Recorded by Dr. DeLong for Columbus.

Empoasca infusca DeLong. Described by DeLong as from Columbus, Canal Winchester, Worthington and Carroll.

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*To appear in Annals Ent. Soc. Amer.

†To appear in Annals Ent. Soc. Amer.

Empoasca bifurcata DeLong. DeLong gives the range of this species as Wisconsin to Northern Pennsylvania and south, so it no doubt occurs in Ohio.

Typhlocyba gillettei var. *sincera* McAtee. Ashtabula Co

Typhlocyba gillettei var. *casta* McAtee. Columbus (H. O.) Madison Co.

Typhlocyba nitidula (Fals.). Ashtabula Co. (E. P. B.)

Typhlocyba nitidula var. *norgueti*. Ashtabula Co. (E. P. B.)

Typhlocyba pulchella McAtee. Ashtabula Co. (E. P. B.)

Typhlocyba phryne McAtee. Ashtabula Co. (E. P. B.)

Typhlocyba antigone McAtee. Madison Co. (E. P. B.)

Typhlocyba appendicula Mall. Williams Co. (E. P. B.)

Typhlocyba rubriocellata Mall. Franklin Co. (E. P. B.)

Typhlocyba cymba McAtee. Little Mt., Lake Co.

Erythroneura mediana Rob. On Elm, Columbus. (H. O.)

Erythroneura beameri Rob. Franklin Co. (E. P. B)

Erythroneura pulchella Rob. Adams Co. (E. P. B.)

Erythroneura rubra Gill. Adams Co. (E. P. B.)

Erythroneura tricincta var. *diva*. Columbus. (H. O)

Erythroneura tricincta var. *cymbium*. Franklin Co.

Erythroneura tricincta var. *integra*. Franklin Co. (E. P. B.)

Erythroneura tricincta var. *calycola*. Adams Co., Franklin Co., and Madison Co.

Erythroneura trivittata Rob. Madison Co. (E. P. B.), W. Jefferson, Franklin Co. (H. O.)

Erythroneura torra. Williams Co. (E. P. B.)

Erythroneura abolla McAtee. In Ohio on Honey Locust. (H. O.)

Erythroneura brundusa Rob. Marietta, Oxford. (H. O.) On Honey Locust, Franklin Co. (E. P. B.)

Erythroneura crevecouri Gill. Additional record, Columbus.

Erythroneura minor Beamer. Recorded for Camp Perry by McAtee.

Erythroneura scripta Rob. Franklin Co. (E. P. B.)

Erythroneura lacta Rob. Franklin Co. (E. P. B.)

Erythroneura amanda McAtee. Adams Co. (E. P. B.)

Erythroneura osborni DeLong. Previous record on mistaken identification.

Erythroneura sp. Not *osborni*.

Erythroneura aclys McAtee. Mistaken identification.

Erythroneura sp. Like *aclys*, but with different picture.

Erythroneura portea Rob.

Erythroneura ligata McAtee. Perry Co. (McAtee). Columbus, May 19, 1928. (H. O.)

Erythroneura vitis var. *stricta* McAtee. Perry Co.

Erythroneura comes var. *rubra* Gillette. Perry Co. (McAtee).

Some very interesting records have been secured by Mr. Virgil Argo from collections made at trap lights on the A. I. U. tower in Columbus. These traps placed at an elevation of 425 feet above street level were run for a number of nights during the summer of 1931 and samples of the leafhopper catch were submitted to me for study. These represented collections made

from June 21 to July 7 and the species and distribution is shown in the following table. The numbers indicated refer only to the number in the samples examined and cannot be taken as a quantitative measure of the relative abundance except in a general way they must indicate the species that were most numerous in the drift of insects going, mainly with the wind, at this distinctly elevated station.

TABLE I.

LEAFHOPPERS AT LIGHT, A. I. U. TOWER, JUNE AND JULY, 1931, 425 FEET ABOVE STREET.

	June 21	June 22	June 23	June 24	June 25	June 27	June 29	June 30 July 4	July 5-6	July 7
Cicadellidae										
Idiocerus pallidus							1			
Idiocerus suturalis								1		
Idiocerus scurra	1									
Macropsis sp.						1				
Macropsis sp.							3	2		
Bythoscopus apicalis						1				
Draeculacephala mollipes	1			2				2		
Draeculacephala sp.								2		
Gypona octolineata										1
Xestocephalus pulicarins						1	1		9	
Xestocephalus sp.?							1?			
Platymetopius frontalis			1				1			
Platymetopius hyalinus								1		
Scaphoideus nigricans								1		
Scaphoideus immistus										1
Deltocephalus inimicus	130	6	50	56	15	21	20	15	20	12
Deltocephalus flavicosta				1						
Euscelis obscurinervis										1
Eutettix seminudus	1					1		1		1
Phlepsius irroratus		1	1	2		2	8	13	1	3
Phlepsius collitus							1			
Thamnotettix nigrifrons							1			
Thamnotettix inornata								1		
Chlorotettix unicolor								1		
Chlorotettix viridius										1
Chlorotettix spatulatus								1		
Chlorotettix galbanatus										

TABLE I—Continued.

	June 21	June 22	June 23	June 24	June 25	June 27	June 30	June 30 July 4	July 5–6	July 7
Cicadula punctifrons			1	1						1
Cicadula sex-notata	1		1							2
Cicadula sp ?										1
Eugnathodus abdominalis										1
Dikraneura sp.						1				
Dikraneura sp.						1				
Empoasca fabae?		3		4	2	3	3		4	1
Empoasca obtusa?		2								
Empoasca sp.?										
Typhlocyba gilletei var.							1			1
Typhlocyba sp.		1	2			1	1			
Typhlocyba sp.							1			
Erythroneura sp.?										1
Membracidae										
Cyrtolobus								1		
Atymna castanea								1		
Micrutalis calva			1							
Fulgoridae										
Cedusa incisa								1		
Stobaera tricarinata								1		1
Liburniella ornata						1				
Delphacodes propinqua?				1						
Aphididae sps.?			1			1				

It will be noted that *Deltocephalus inimicus* was most numerous and in the catch of every night from June 21 to July 7. *Phlepsius irroratus* was second and represented in all catches except June 21 and 25.

These records indicate extended migration and wide dispersal as well as attraction to light and ability to reach higher strata of air. Some of the species included are rarely taken in collecting; some of them doubtless arboreal and out of reach for ordinary sweepings. Many are willow feeding, some oak and many grass with range from Xerophytic to Hydrophytic in habitat.

NATIONALISTIC ELEMENTS IN FARMING ON THE LAKE PLAINS OF NORTHWESTERN OHIO.

CARL DUDLEY VARVEL,
Ohio State University.

NATIONALISM.

The population map for Ohio shows that the rural population of Northwestern Ohio is well distributed. (Pl. I, Fig. 1.) The density of population averages for this area 60 per square mile, compared with 163 per square mile for the entire state and 42 per square mile for the United States.

A cursory examination of family names indicates that in the towns and villages the population is well mixed so far as the national origin is able to be identified. Biological mixing occurs more readily in urban areas than in rural areas. In the latter there is evidence of the persistence of nationalistic homogeneity where for example German marries with German, Pole with Pole or Old American with Old American. This may be due either to geographical propinquity or social inertia in choosing the marriage path of least resistance, but the consequences are that certain traits of nationalism are continued and accentuated.

LAND VALUES AND SETTLEMENT.

The Lake Plain counties are rich farming lands. Eleven counties of Northwestern Ohio which compose it in whole or in part contain about 9% of the area of Ohio, yet they hold about 18% of the farm wealth of Ohio. Land values in four counties—Wood, Henry, Putnam, and Paulding, whose soils are almost wholly composed of lacustrine sediments, were appraised on April 1, 1930, at an average of $104 per acre, which was 25% higher than the average farm value for Ohio. This was the last extensive area of Ohio to be occupied by the pioneer. The swampy character of these plains of low relief (Fig. 2) retarded settlement as long as better lands were available.

LAND USE.

These lands are normally devoted to a regime of mixed grain farming associated with the raising of livestock and poultry. Corn, oats, wheat, soybeans and alfalfa are the principal cultivated crops and are everywhere grown in rotation. In addition 90% of the sugar beets grown in Ohio are produced here. Relative proximity to Toledo and Detroit, thanks to numerous hard surfaced highways and speedy motor trucks, has stimulated truck farming and market gardening. Sandy well drained soils of the old lake beach ridges (Fig. 3) favor vegetable cropping on a large scale. (Fig. 5.) Owing to the tempering influences of the cool lake waters, fruit trees escape the hazards of early budding. Specialized fruit culture, particularly as related to apples, peaches, and grapes, is highly successful on the lake peninsula of Ottawa county—the Port Clinton area—as well as on the valley slopes of the Upper Maumee River. Practically every general farm has an orchard which supplies domestic needs.

THE PIONEERS.

The first efforts made by Europeans and their descendants to occupy the territory in any capacity were made by the French trappers and traders in 1680. English traders began to establish themselves in opposition to the French about 1700.* The earliest farmers were doubtless the descendants of the French and English trappers. Some farmers of Yankee and other old stocks filtered into the area in the decades after the Revolutionary War as part of the "Westward Movement." The well drained lands of the beach ridges were the first to be settled for most of the area was of a swampy nature and heavily wooded.

In the year 1820 the population of the "Lake Plains Counties" was too small to be counted in the decennial census. By 1830 the "Swamp land" Counties—Wood, Henry, Paulding and Putnam—contained less than two thousand persons. In 1860 these contained nearly 45,000 inhabitants. In 1930, a century of population growth showed that these counties contained 113,219 inhabitants. Such population figures indicate that settlement was rapid once the movement for land improvement was started.

*Knapp: History of Maumee Valley. Toledo, 1877, p. 10.

THE GERMANS.

The traveler is likely to be impressed by the large number of people bearing names of obvious German origin. Germans began migrating to Northwestern Ohio at a rather early date. The first settlement in Fulton County was made in German Township in 1834 by a group of Amish Mennonites from Mülhausen in Alsace. The farm lands of this same township in 1932, nearly a century later, are owned almost exclusively by the thrifty descendants of these pioneers. One community leader* said that there is not a farm mortgage in the township. German Township is one of the best corn producing areas of Ohio and is locally noted for the feeding of swine and beef cattle.

The first recorded German settlement in Wood county was made in Perrysburg township in 1852 by a group of Roman Catholic families from Munich in Bavaria. The families were large and the settlement prospered. One historian has said, "They deserve especial credit for they came before the improvement of lands had begun." Other groups of German people came during the decades before and after the Civil War, many from abroad and others principally from German settlements in Pennsylvania.

These German migrants coming into the area later and with meager funds found the unoccupied swampy lands for sale at a relative low price, since the presence of timber and swamp vegetation precluded their use for agriculture. However, these poor lands offered an advantage, for unlike the forested lands encountered by the pioneers in southern and central Ohio, there was a market for timber. Many local hoop mills and stave factories consumed both elm and oak lumber. The shipyards at Toledo bought readily the larger and finer trees of oak.

The German pioneers, as well as others, had a common method of attacking the problem of land clearing and drainage. In general a pioneer bought a few acres of forested land from the state, cleared and drained an acre or two the first year and planted a crop as soon thereafter as possible. With the money received from the sale of the timber, he bought a few more uncleared acres and improved them. He used the proceeds from the sale of the timber and foodstuffs to extend and improve his land holdings.

*A newspaper editor at Archbold, Ohio.

The German farming people were derived generally from the tenant agricultural classes of "The Fatherland." They knew by experience the conditions of hard physical work, long hours of toil, self denial of many things and too, necessary thrift. As a race of pioneers they brought much in physical and mental energy which has been inherited by their descendants. They knew the soil intimately because of the practices of hand-and-knee labor in the homeland. Constant fertilization of soil was not scoffed at by those whose forbears for hundreds of years had been farmers. "Long hours of labor were joyous when they felt certain that it would bring a money reward and as well the pride of land ownership," one of them said to the writer.

Their religion, either Protestantism or Roman Catholicism, taught humility and simplicity in the daily needs, for they of recent European origin had long believed themselves to be destined for a lowly place in society. Religion taught, especially to the Amish Mennonite, a positive injunction against the display of wealth in costly clothes, "showy" furniture, spirited horses or other elements of culture displayed by others. These German folk could without pain put the profits of the farm back into their lands. They built them up until today many of them are model farms and in ordinary times bring more than average financial returns.

In contrast, other farmers of non-Germanic stock are reported to have followed the practice of taking the profits away from the lands until their holdings of similar physical structure have become of nearly marginal productivity. As marginality acts, the German farmers are frequently in a position to purchase these lands and subsequently restore them to productivity of a higher order.

A widespread characteristic among the German farmers as among successful farmers everywhere is the work-plan for doing the repair job needed to be constantly performed on any farm. Among them it is axiomatic to put aside such repair work to be done indoors, such as harness, tool and implement repair, until a rainy day prevents outside labor. Other farmers it is averred, make no definite programs, hence on rainy days when the Germans are accomplishing their repair jobs, the village loafing places are often crowded by farmers of other nationalities.

From observation one can say, and not untruthfully, that nine out of ten neat farmsteads are owned by German farmers, or that nine out of ten sloven farmsteads are not German farmsteads. Characteristic of German farms are well kept, spacious farmhouses, well planted and cropped yards (Fig. 6), large barns well designed and constructed, for the storage of hay and machinery and for feeding indoors large numbers of cattle. (Fig. 7.) The barns generally are painted white with the owners name in large letters conspicuously displayed. The farmyards are in most cases gravelled and clean enough to accommodate a picnic dinner at anytime without offense. The fences and gates reveal an air of farm prosperity. These conditions are not exclusive among the German farmers but are characteristic of them.

POLES.

Polish farmers of the Lake Plains of Northwestern Ohio are found today largely in "the Oak Openings." The "opening" is an area of predominantly sandy surface material which lies west of Toledo in the southwestern part of Lucas County. It extends into southern Fulton County and into northeastern Henry County. It is a heterogenous growth of flora associated with the oaks, generally infertile in an agricultural sense, cleared and kept cleared with difficulty (Fig. 9). It is a land which supports a bare subsistance economy. Most of the Polish people living on these lands are there not because of any special farming ability they may possess, but because economic conditions have repelled them from the urban industries. A few acres of this land offered something of a refuge. The Poles are handicapped in several ways; the land is inferior and the competition of the Germans on the better lands creates an economic hardship from which there is little relief. These Polish people support large families which offer much potential farm labor. With the handicap of infertile land this labor cannot be employed to any special productive advantage. The large family is a consuming family and possibly accentuates the poverty induced by the land.

At most the "Oak Openings" provides very poor pasturage, and equally poor cereals. There is the culture of some melons, berries, grapes and little else. Commercial vegetable cropping has not been satisfactory due to competition of the better

lands. Farm buildings (Fig. 8) seem to reflect the poor quality of the land and holdings are pitiably small in contrast with those of the Germans.

SWISS.

There are notable German Swiss settlements in Putnam County, largely on the Lake Plain. These include prosperous people who have built their lands to a high degree of productivity. The teachings of the Mennonite Church have shown a marked influence here as in German Township in Fulton County, already mentioned.

OLD AMERICANS.

Yankee and other Old American peoples are generally distributed throughout rural northwestern Ohio, but they seem to be less common than those folks of German origin. It is safe to suggest that many of these older peoples have moved from the worn out lands to newer and better lands while others have felt the call to the cities where wages and salaries appealed more than the land. It must be said, however, that many of the descendants of these old families are today eminently successful farmers where they have pursued the methods used by the Germans.

CONCLUSIONS.

From these observations it seems evident that among those people of known national origins in this widespread farming area certain elements have played a conspicuous part in its agricultural development. The inherently good qualities of the German farmer as a soil manager, his willingness to work long hours, the fertility of the newly drained soils, the early initial advantage of the sale of the timber and the good market for the sale of agricultural products have all combined to make his position a secure one and his contribution to agricultural advancement not only of local importance but of value to the state.

EXPLANATION OF PLATE.

FIG. 1. Population Map of Northwestern Ohio, by Guy-Harold Smith. Courtesy of the Geographical Review, published by the American Geographical Society of New York. The dotted line represents the shores of glacial Lake Maumee, after Leverett, Monograph 41, U. S. G. S. pp. 50–51. The map indicates the uniformity of rural distribution.

FIG. 2. The Lake Plains comprise thousands of acres of land of distinctly low relief.

FIG. 3. The "beach" of ancient glacial Lake Maumee rises gradually from the "lake" floor. It is the site of highways and many farm houses.

FIG. 4. Large drainage canals near Lake Erie are necessary. Capillary water which threatens the farm lands is pumped constantly into these channels.

FIG. 5. Commercial vegetable growing is characteristic of the sandy soils. (The photo shows a portion of a field of eggplant.)

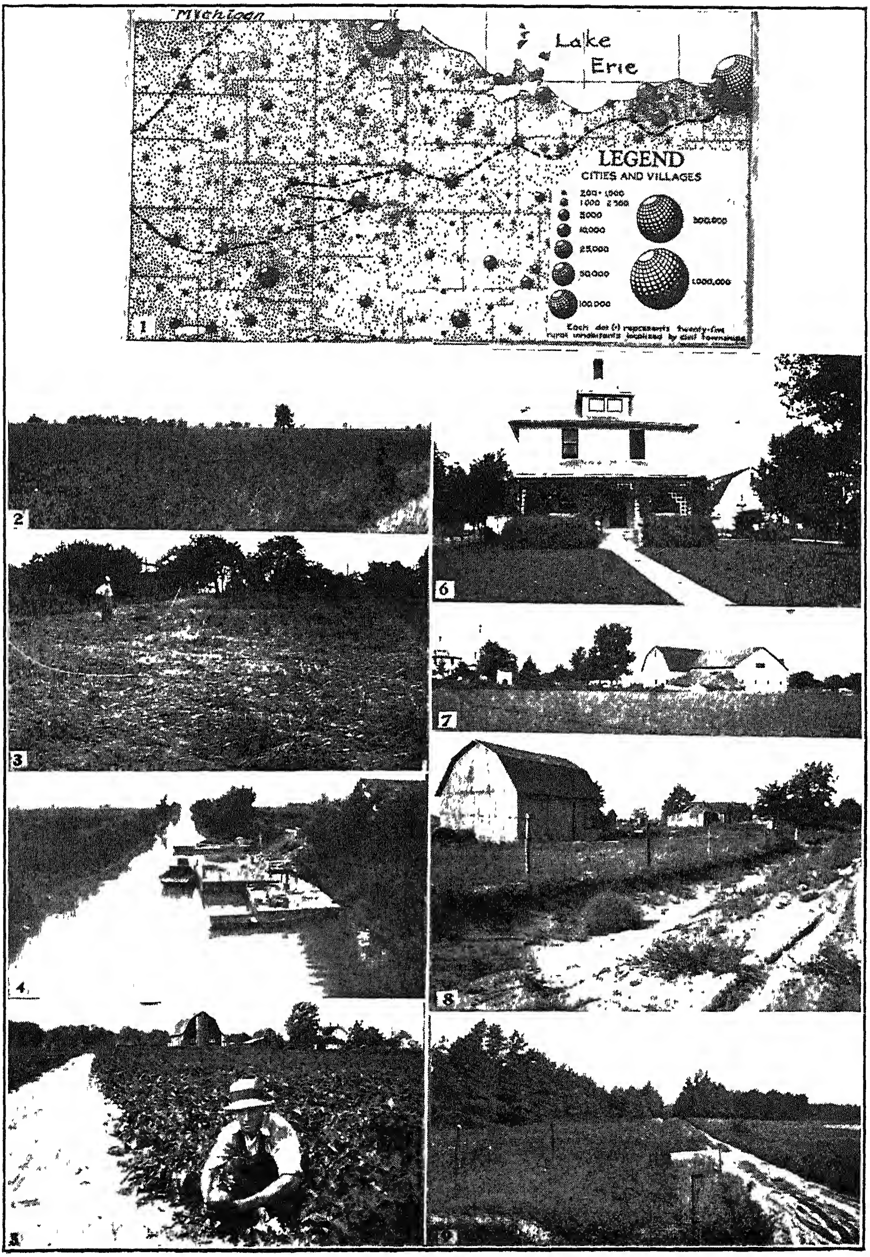
FIG. 6. Buildings on most "German-owned" farms carry an air of neatness and reflect thrift. Well planted yards and lawns are common characteristics.

FIG. 7. Most German farmsteads are well arranged. (The house is shown in Fig. 6.)

FIG. 8. The farmsteads in the "Oak Openings" are indices of the relative poverty of the soils. These farmsteads are in striking contrast with those of the better lands.

FIG. 9. Most of the arable lands in the "Oak Openings" are used for pastures which ordinarily have a low "carrying capacity."

PLATE I.


Michigan
Lake Erie
LEGEND
CITIES AND VILLAGES
5000
10,000
25,000
50,000
100,000
1,000,000
1
2
3
4
6
7
8

SOLUTION PHENOMENA IN THE BASAL ONEOTA DOLOMITE.

WM. A. P. GRAHAM,
Ohio State University.

The systemic contact between the Cambrian and Ordovician formations in the upper Mississippi valley occurs between the Jordan sandstone and Oneota dolomite, of Cambrian and Ordovician age, respectively. An erosional unconformity at this contact is suggested by a red residual clay zone, present at places along the contact, and to irregularities in the normal bedding of the sandstone and dolomite.

The red clay is not always present below the dolomite, but is developed where evidence of solution of the dolomite is found. The Oneota is strongly jointed from the present surface to its base. Effect of solution along the joints is shown by the smooth, rounded, and somewhat undulatory joint surfaces and also by the concentration of iron oxide and clay so frequently found coating the surface of the dolomite in these channelways.

The joints are now filled with silt and sandy silt which very closely resemble the clastic material occurring immediately below the dolomite. The bedding in the joint filling material bends downward at the walls of the joints in the lower portion of the openings but no structure occurs in these fillings in the higher portions of the joints. The clastic material below the dolomite is deformed in many of the outcrops, the greatest deformation is below the zone of most intense jointing. At these places the undeformed stratification of the sandstone can be followed beneath a large joint where striking re-entrant angles have been formed by solution widening at the bottom of the joints. These re-entrants frequently penetrate the dolomite several feet. The otherwise horizontal bedding planes arch into such joints in miniature anticlines which show squeezing on the flanks with thickening at the axes. Material from the axes is clearly squeezed upward into the joints for considerable distances. Figure 2 illustrates the deformation of the clastic material at the base of a joint where solution has enlarged it. The Oneota is invariably broken and disturbed by settling where these clay and sandstone re-entrants and joint fillings occur, the intensity and size of the fractures in

the dolomite is proportional to the squeezing displayed in the sandstone.

Winchell and Upham* noted these irregularities at the base of the dolomite at numerous points along Minnesota river and its tributaries. They suggested downward migration of Cretaceous clays and silts along joints in the Oneota during Cretaceous time and assumed the clays were then carried into widespread solution cavities at the base of the Oneota where the stratification developed in these clays conformed to the shape of the openings.

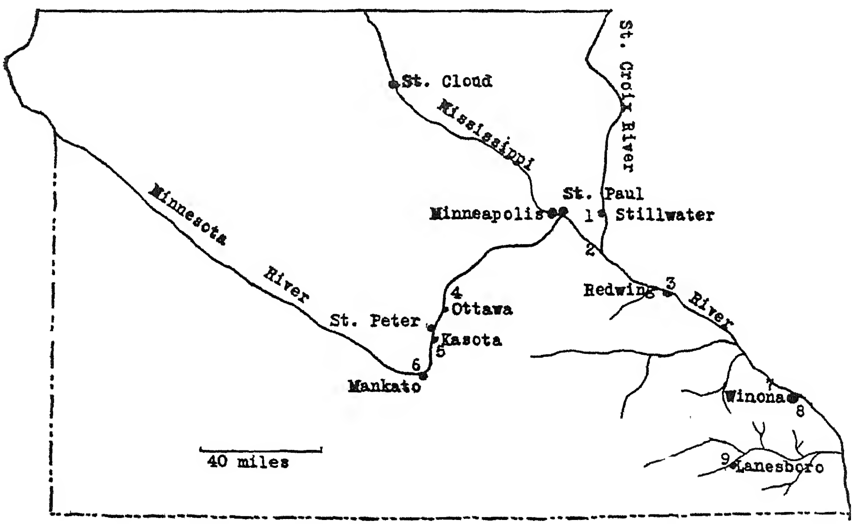


FIG. 1. Southern Minnesota. Numbers indicate location of sections studied in detail.

The numerous joints in the Oneota dolomite furnished excellent channels for downward flowing waters. On reaching the sandstone the waters spread laterally, developing small solution cavities at the base of the dolomite over rather extensive areas. This phenomenon would be especially developed at a time when the level of the groundwater table closely approached the contact plane between the two formations. The top of the Jordan, shown in Figure 2, is a fine-grained water-bearing sandstone. The fineness of the texture even at

*Upham, Warren: Geol. and Nat. Hist. Surv. of Minn., Vol. I, pp. 432–438, 1872–1882.

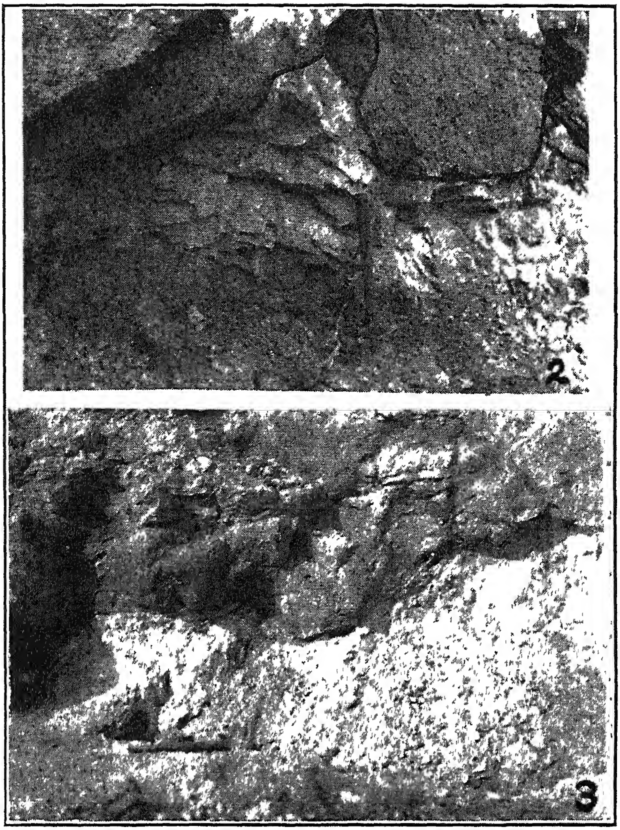


FIG. 2. Deformation of the fine-grained clastic material by solution and settling of the overlying Oneota dolomite. Penetration of the folded bed into a joint plane is well shown. Silbey Park, Mankato, Minn.

FIG. 3 Solution and settling of the Oneota has resulted in deformation of the underlying clastic material. Exposure at St. Peter, Minn.

present causes the water to be held for some time after the coarser underlying layers are dry. Water passing downward along the joints in the Oneota is slowed up in its downward motion on reaching this fine sandstone, resulting in lateral spreading, giving rise to the conditions necessary for the accomplishment of the observed solution effects. In Figure 3 the relationship between a medium-textured phase of the Jordan in contact with the Oneota is shown. The sandstone is massive, thus masking the irregularities in the bedding planes although the irregular re-entrants at the contact are very well developed. Downward moving waters would not be slowed up under such conditions on reaching the sandstone unless the groundwater table roughly coincided with the contact of the sandstone and dolomite. Since extensive solution did occur under this condition the above relationship is assumed to have existed at some time prior to the settling of the dolomite into its present position.

As solution progressed the sandstone below was deformed and squeezed into its present position by settling of the dolomite due to irregular sinking of the unsupported and weakened portions. In some cases the sandstone has been forced 15 to 20 feet upward along the joints in the dolomite, at times it no doubt was forced even greater distances upward, but erosion has removed the higher beds so no greater measurements were secured. It is assumed that settling of the dolomite approximately kept pace with solution, preventing accumulation of irregular dolomite blocks on the floor of the caverns, since no such blocks have been found. The deformation of the very fine-grained friable sandstone or silt zone at the top of the Jordan is expressed by an irregular series of small folds definitely showing thinning on the flanks with thickening along the axes. These folds have their axes under joints in the dolomite which have been filled by the injection of the sandstone during the period of settling of the blocks. On the highway from Mankato to New Ulm, a short distance out of Mankato, maximum deformation of the Jordan was observed. Here the Jordan has been squeezed into folds 10 to 15 feet high. At this locality the Oneota shows the effect of fracture and settling very clearly by the great disturbance in the normal bedding.

At several localities, Stillwater, Ottawa, St. Peter, Mankato, and numerous places noted by Winchell and Upham, concentrations of iron oxide and clay ranging in thickness from a

fraction of an inch to several inches occur beneath the dolomite and along the walls of the numerous joints. This concentration of iron oxide and clay suggests circulation of ground water which dissolved the dolomite along these joints and at the contact of the dolomite and underlying clastics. It is not thought that these concentrated materials indicate a residual accumulation on an ancient land surface since they not only occur at the base of the dolomite but also along the edge of joints widened by solution.

Solution of this sort would result in a concentration of the residual minerals of the Oneota on the top layer of the Jordan sandstone. At one locality, Ottawa on Minnesota river, such a concentration occurs.

The time during which the Oneota settled into the upper Jordan can not be definitely stated, but was no doubt when the competency of the dolomite was low. Settling occurred either when sufficient reduction in thickness of the poorly supported formation was accomplished, or when the added weight of one of the Pleistocene ice sheets increased the load beyond the strength of the weakened formation. It is thought that the settling took place in Tertiary or post-Tertiary time, but no evidence can be presented in support of such a view other than a theoretical consideration of the thinning necessary for failure of the formation.

Heredity in Man.

A British biologist presents in this volume a most interesting and valuable account of the applications of genetic principles to man's welfare. The determination of the type of inheritance involved in human characters is not at all the relatively simple problem which it proves to be in many plants and animals. Methods for such determinations in man are presented and discussed. The possibilities and limitations involved in the mapping of human chromosomes are touched upon. Twins and their bearing on problems of human heredity are taken up with a precise analysis of existing material. Races, populations, and social groups are all subjected to the same genetic analysis, with the result that some of the older orthodox "rule-of-thumb" genetic pronouncements are severely shaken.—L. H. S.

Genetic Principles in Medicine and Social Science, by Lancelot Hogben. 230 pp. New York, Alfred A. Knopf Co., 1932.

OBSERVATIONS ON SEMI-DESERT ANTS.

A. C. COLE, JR.,
Ohio State University.

I. Early Spring Temperatures of Ant Mounds in the Sagebrush Semi-Desert.

The two most prominent ant mounds in the sagebrush semi-desert area of southern Idaho are those of *Pogonomyrmex occidentalis* Cresson and *Formica rufa obscuripes* Forel. They occur in great abundance at Twin Falls, Idaho, those of the former scattered and those of the latter grouped. The collection of temperature data was begun on March 21, the first calendar day of spring.

In early spring the interiors of mounds of *P. occidentalis* are only slightly warmer than the exteriors. This is particularly true of mounds composed entirely of pebbles which do not tend to absorb heat as rapidly as do those of detritus. Temperature varies with depth, being higher toward the surface of the mound and lower with descending progression. The highest temperatures occurred at a depth of approximately four inches and the lowest at eighteen. Temperatures at various depths in an average sample of each type of mound are shown in Table I and Figure 1. The air temperature at the time of these measurements (2 p. m.) registered 40 degrees Fahrenheit. Note the gradual decrease in temperature at increasing depths below four inches. This partly accounts for the fact that in early spring the majority of ants of this species are situated at the optimum temperature level of about four inches.

Formica obscuripes is the first ant to become active in the early spring in the vicinity of Twin Falls. It builds dome-shaped mounds of sticks and leaves which are generally formed around large plants of sagebrush (5). Figure 2 illustrates typical mound temperatures on March 31, 1932. Note the contrast between temperatures within the mounds and those of adjacent soil. The highest mound temperature obtained was 80 degrees Fahrenheit and occurred six inches below the mound surface. There was a decided drop in temperature

between the six and the two inch level. The temperature of adjacent soil, on the other hand, was slightly higher at two than at six inches and there was a marked increase from the two-inch level to the soil surface. At the time these temperatures were recorded (11 a. m.) the air temperature in the shade registered 68 degrees Fahrenheit and 70 degrees in the sun. The surface temperature of the shady face of the mound was recorded as 80 degrees and that of the sunny face as 94 degrees.

TABLE I.

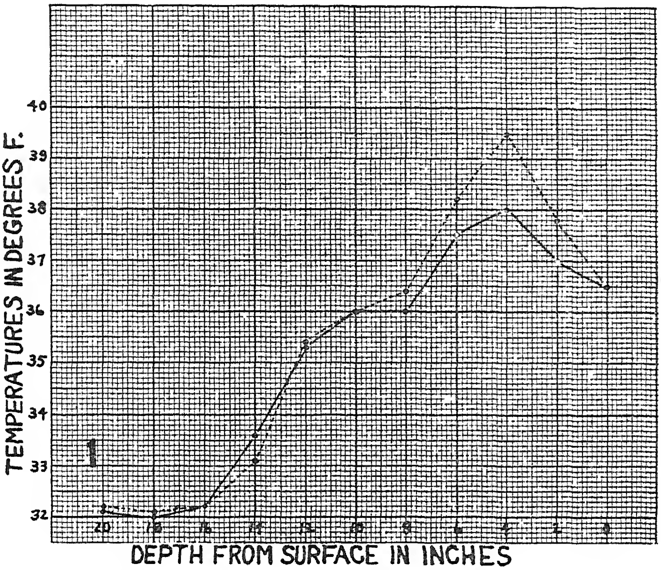
Typical Early Spring Temperatures of Mounds of *Pogonomyrmex occidentalis* at Various Depths.

Depth	Temperature Pebble Mound	Temperature Detritus Mound
0 inches	36.5 F.	36 5 F.
2	37 0	37 8
4	38 0	39 5
6	37.5	38 2
8	36 0	36 4
10	36 0	36 0
12	35 3	35 4
14	33 6	33 1
16	32 2	32 2
18	32 0	32 1
20	32 1	32 2

The faces of mounds of both species attain higher temperatures than does the adjacent soil surface because the rays of the sun on the faces are more intense than on a like area of soil surface. This point is diagrammatically illustrated in Figure 3. Only when the sun is directly overhead are its rays, directed upon both the mound and adjacent soil, of equal intensity. During the greater part of the day one face of the mound tends to lie more or less perpendicular to the sun's rays, while the rays are more dispersed on the level soil adjoining the mound.

LITERATURE.

(1) **Andrews, E. A.** "Ant mounds as to temperature and sunshine." *Jour. Morph. and Physiol.*, XLIV (1927), 1–20.
(2) **Idem.** "Sequential distribution of Formica exsectoides Forel." *Psyche*, 1926.
(3) **Cole, A. C., Jr.** "The ant, Pogonomyrmex occidentalis Cr., associated with plant communities." *Ohio Jour. Sci.*, XXXII (1932), 10–20.
(4) **Idem.** "The relation of the ant, Pogonomyrmex occidentalis Cress., to its habitat." *Ohio Jour. Sci.*, XXXII (1932).
(5) **Idem.** "The ant Formica obscuripes." *Psyche*, June, 1932.
(6) **Field, A. M.** "Temperature as a factor in the development of ants." *Biol. Bull.*, IX (1905).



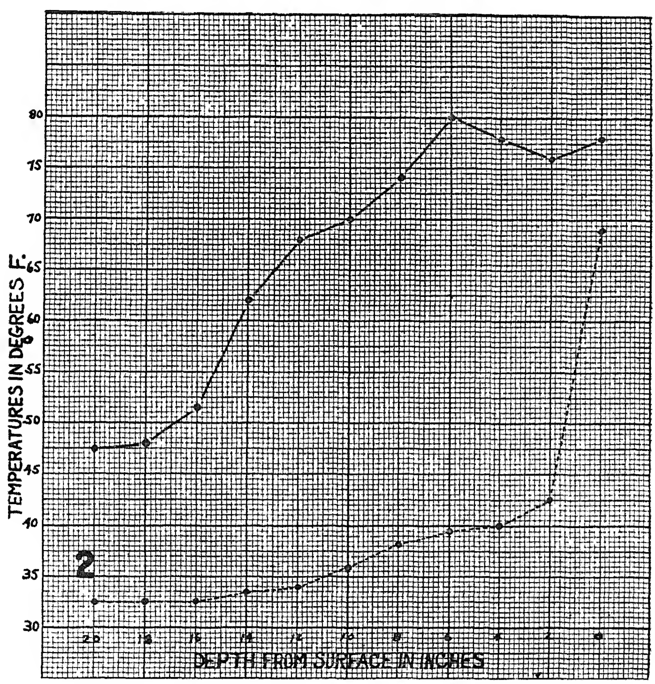


FIG. 1. Typical early spring temperatures, at various depths, in mounds of *Pogonomyrmex occidentalis*. The solid line represents temperatures of a pebble mound and the broken line those of a mound of detritus.

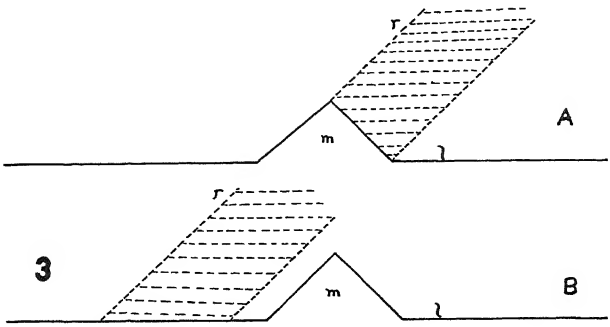
FIG. 2. Typical early spring temperatures of a mound of *Formica rufa obscuripes* and an area of adjacent soil. The solid line represents temperatures of the mound and the broken line those of the adjacent soil.

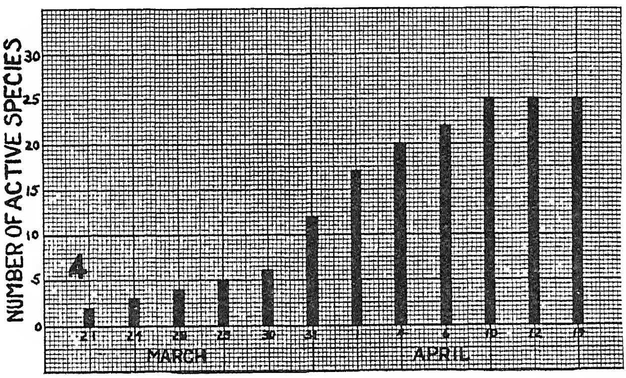
II. Increase in Early Spring Activity of Semi-Desert Ants.

Observations on the increase in the number of species of ants becoming active from the first calendar day of spring to the middle of April, 1932, were made by the writer in the Twin Falls Area, Idaho.

On March 21 two species of ants were decidedly active in this section, namely, *Formica rufa obscuripes* Forel and *Tapinoma sessile* Say. The temperatures within the detritus mounds of *F. obscuripes* were much higher than the prevailing atmospheric temperatures, (Part I of this paper; also reference (3)). *Tapinoma sessile*, on the other hand, is one of our most hardy ants and is quite active even under low temperature conditions. On March 24 the Occident Ant (*Pogonomyrmex occidentalis* Cresson) began activity and removed the grass coverings from its pebble mounds. March 28 marked the initial date of early activity of *Lasius niger americanus* Emery; March 29, of *Formica subpolita* Mayr; March 30, of *Formica fusca subsericea* Say; March 31, of *Lasius umbratus mixtus aphidicola* Walsh., *Formica neogagates neogagates* Emery, *Camponotus hyatti* Emery, *Leptothorax curvispinosus rugatulus* Emery, *Crematogaster lineolata* Say, and *Monomorium minimum* Buckley; April 1, of *Formica sanguinea puberula* Emery, *F. cinerea neocinerea* Whlr., *Solenopsis molesta validuiscula* Emery, *Myrmica rubra scabrinodis* Nyl., and *Myrmecocystus melliger semirufus* Emery; April 4, of *Leptothorax melanderi* Whlr., *Iridomyrmex pruinosus* var., and *Myrmica sp.;* April 6, of *Myrmica mutica* Emery and *Brachymyrmex sp.;* and April 10, of *Pheidole sp.*, *P. vinlandica longula* Emery, and *Lasius niger sitkaensis* Pergande. Figure 4 shows the increasing number of active species from March 21 to April 10, 1932.

The first to venture forth from their winter quarters were those species which occupied deep canyons. In such habitats the average temperatures were somewhat higher than on the semi-desert plains. Those species whose nests were on south- and east-facing hillsides were the next to exhibit signs of activity, this again being a temperature relationship. Next appeared those species in areas of shrubby vegetation, and then those whose nests were on the dark-colored sand plains, where the surface tended to absorb a large part of the sun's rays. Last to make their appearance were those species on





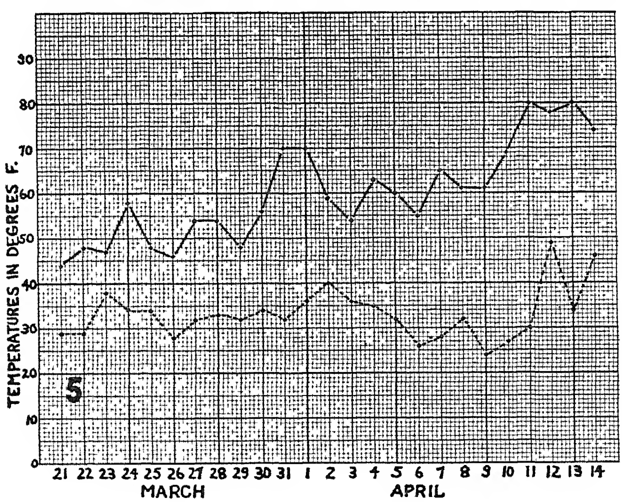


FIG. 3. Diagrammatic representation of the angle of contact of the rays of the sun. (A), rays directed against the face of a mound of *Formica obscuripes*, and (B), those directed on an area of adjoining soil surface. m, mound; r, rays of sun; l, ground level.

FIG. 4. Active species of ants at different dates.

FIG. 5. Gradual increase of daily temperature.

the lighter-colored sand plains, where much of the heat was radiated and where the soil temperatures were not so high as on the darker sands. Thus we have a gradational series of active species in a variety of habitats, from the latter part of March to the warmer days of mid-April.

The increasing early spring activity of semi-desert ants can be explained on the basis of increasing maximum and minimum daily temperatures. So closely is temperature connected with a complexity of other factors that we cannot separate it from the others, but merely place it as dominant in this particular case. Note the gradual increase of daily temperatures in Figure 5. In spite of major and minor fluctuations the increase is rather well marked, especially in the case of the maximum temperature curve. The high maximums between March 30 and April 1 ushered in eleven kinds of ants, the greatest number of additional species appearing at any one time. The most sun-loving ant of the series, *Myrmecocystus melliger semirufus*, appeared on April 1 at a maximum temperature level of 70 degrees Fahrenheit. In spite of the high maximum temperatures on days following April 10, no additional species were observed in an active condition (Figure 4).

LITERATURE.

(1) **Cole, A. C., Jr.** "Nests of the ant, Formica subpolita Mayr, in the western United States." (In press, *Ohio Jour. Sci.*).

(2) **Idem.** "Ant communities of a section of the Sagebrush Semidesert in Idaho, with special reference to the vegetation." (Unpublished manuscript.)

Idem. "The ant Formica obscuripes Buckley." *Psyche*, June, 1932.

(4) **Wheeler, W. M.** *Ants: their structure, development, and behavior.* Columbia Univ. Press, 1926.

THE VALUE OF AN OBSERVATION HIVE OF HONEYBEES IN THE TEACHING OF HIGH SCHOOL BIOLOGY.

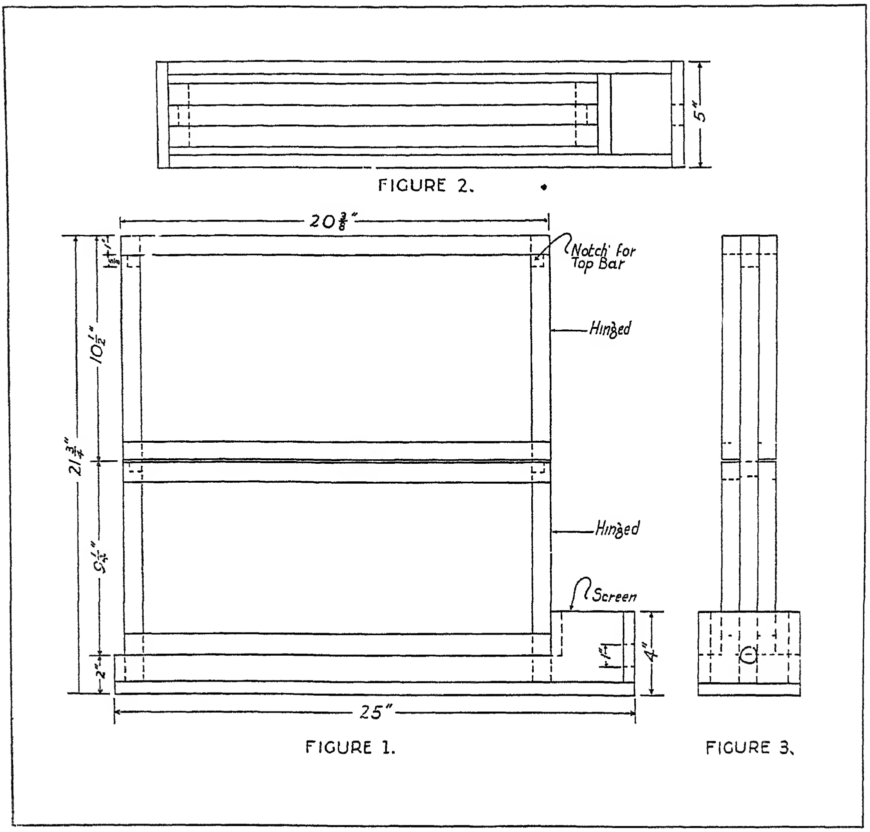
ALMA A. KEELER,
Columbus, Ohio.

Observation hives had their origin in antiquity when small pieces of transparent substances such as horn, isinglass, and mica were placed in the sides of the hives. Such windows offered only a very meager opportunity for studying the behavior of the bees. A hive with a glass window was invented by Mr. W. Mew of Easlington, Gloucestershire, England, about 1650. In 1730, Reaumur, the French naturalist placed a swarm between two panes of glass. The panes were too far apart and the bees built a row of comb on each pane, thus becoming hidden in the center. Bonnet, the Swiss naturalist recommended a hive with doors and having a space that only one row of comb could be built. About 1790, Huber adopted this plan, with the result that great advancement was made in the knowledge of bee life.

Commercial beekeepers have used observation hives extensively for advertising purposes. A frame of brood and honey together with sections are placed in the observation hive. This is kept in the display window for a week or until most of the people in the vicinity have seen it.

In the school laboratory, it is one of the most convenient ways of showing the complete metamorphosis of an insect. Cells may be seen that contain eggs. If these are watched, the development of a larva can be traced to the time that the cell is sealed indicating that pupation is taking place. After pupation, the adult will cut its way out of the cell. The fact that the life history is short makes it possible to trace through the life of an individual insect in a comparatively short time. There is the added value that all stages may be present at the same time. There are few other insects so well adapted to live in the confinement of the schoolroom and at the same time to carry on its normal work.

Social organization among the insects is at its peak among the bees. They are pointed out as the best illustration of



OBSERVATION BEE HIVE.

Designed by Dr. W. E. Dunham.

Drawn by K. D. Powers.

BILL OF MATERIAL.

2 pieces ½" by 3½" by 24"
1 piece ½" by 5" by 25"
8 pieces 1" by 1" by 20⅜"
4 pieces 1" by 1" by 10½"
4 pieces 1" by 1" by 9¼"
2 pieces 1" by 1" by 21¾"
1 piece 1½" by ½" by 5"
1 piece 2" by ½" by 5"

1 piece 3½" by ½" by 3½"
2 pieces of window glass 18⅞" by 9"
2 pieces of window glass 7¾" by 9"
4 small hinges
2 small hooks
1 piece of screening 5" by 25"
2 standard Hoffman frames

Inside measurement of glass must be exactly ⅜" from edge of the top bar of the Hoffman frame.

Both sides may be hinged, but only one side is recommended.

Use an end lap joint on upper frames. All other joints are butt joints held by screws.

communistic life that has yet been evolved. The sacrifice of the individual for the group is seen as each insect uses itself to the utmost to promote the life of the colony. Its labors are never ended as long as there is food that it can gather.

Division of labor begins with the emergence of the adult bee from the cell. The newly emerged worker bees remain in the hive for about two weeks and can be seen doing a variety of kinds of work such as feeding the larvae, making wax,

building comb, cleaning, ventilating, and guarding the hive. As they become older, they fly out on short flights. Soon they will be making longer trips and can be seen coming in with either abdomen distended and full of nectar or the legs covered with pollen. Perhaps they will have both. They store their load in the cells and are ready for another trip in a remarkably short time. They are then called field bees and they continue this work for weeks or until they become worn and exhausted and can no longer get back with the last load.

The queen bee will be observed going about inspecting the cells and laying eggs in the empty ones. When she stops to rest, the nurse bees immediately gather about and feed her.

In winter, when egg laying has ceased, she feeds herself. Queens live several years.

A few drones may be seen but they either die naturally or are killed by the workers before winter comes.

The study of the bee incidentally makes one better acquainted with an occupation through which thousands earn their entire livelihood. There are over a million people who keep bees either for pleasure or profit. The annual value of honey in the United States is forty million dollars and the estimated value of bees as pollinating agents is eight hundred million dollars. The value of the wax produced is about six million dollars.

It is also beneficial for the student to see the cleanliness of the bee and consequently to understand the wholesomeness of a product that is supplied from nature's own laboratory, the nectaries of the flowers. It might be noted that honey is one of the most healthful of foods because of the ease of digestibility, being more readily digested than sugar and that it contains a useful mixture of minerals, possibly one of the vitamines, and at least four enzymes.

Plans for the making of an observation hive are shown in Figures 1, 2, and 3. The amount and kind of material are given. The building of the hive could doubtless be done in cooperation with the manual arts department.

The hive can be stocked in the fall or early spring depending on its intended use. If it is stocked in the fall, and the bees are to be carried over the winter, the observation hive as shown in Figure 1 should have a frame of honey placed above and a frame of emerging brood with a queen below. The honey should carry them over the winter but if it runs low they can be fed with a syrup made of one part of sugar and one part of water.

If the hive is installed in the spring, there must be sufficient food to last until the bees can accumulate enough for themselves. The lower frame may be drawn comb or comb foundation. The latter would be more interesting as the bees would have to build it out before egg laying could begin.

Bees may be obtained from a commercial bee supply house or a beekeeper in the vicinity might be glad to stock the hive. The kind of bees is not important. However the Italian bees are usually preferred as they do not bring in so much unnecessary propolis.

The hive can be located at almost any convenient place in the laboratory and a rubber tube used to connect it to the outside of the building or outside of a window. The bees will readily use this entrance. If the hive can be near a window, it may be placed on a level with the window sill so that the entrance will pass under the window sash. The space on each side is closed with boards.

The hive, if properly stocked, requires little attention other than to see that there are sufficient stores and that the temperature does not fall to freezing without the hive being covered. If the honey supply is low, sugar syrup must be given.

A certain amount of dwindling may be expected but on the whole, the bees will set up housekeeping, go to the fields when the weather permits, and carry on their ordinary work as though there were no prying eyes to see and with small loss in numbers.

The Study of Life.

This English biology written for students preparing for the School Certificate Examination is a very attractive book. In size and make-up it compares very favorably with our recent High School texts. It is built largely of a series of topics which center around the study of type forms. However, many of the newer physiological ideas are included. It is a pleasure to find a biology of this kind in which respiration and energy release are correctly treated. Throughout the book the basic ideas of cause and effect are clouded by the usual teleological statements which involve purpose and need. Thus on p. 67 one reads, "Secondly, water is the basis of all protoplasm, so the plant needs it for that reason." The numerous illustrations are excellent and are appropriate in the places where they are used.—W. M BARROWS.

Biology: An Introduction to the Study of Life, by H. Munro Fox. 332 pp., 151 figures. Cambridge, The University Press, (in U. S. A. The Macmillan Co.). 1932.

THE JOURNAL CHANGES EDITORS.

At the recent meeting of the Administrative Board of the Ohio Journal of Science, Prof. Herbert Osborn requested that he be relieved of his duties as Editor of the Ohio Journal of Science, in order that he might have more time to devote to other interests. Prof. Osborn's resignation was accepted by the Board with expressions of regret and of sincere appreciation for his services during the three years he has served as Editor of the Journal. Dr. Osborn's successor as Editor will be Dr. L. H. Snyder, who was elected unanimously by the Board to fill this position. Dr. Snyder is well qualified for this post, having served the Journal during the past year as Associate Editor. By a decision of the Board the position of Associate Editor will not be filled, at least for the time being. The entire present Editorial Staff was also re-elected for the coming year. However, the Board also put itself on record as favoring some plan limiting the period of service of the members of the Editorial Staff, so that the term of office for a certain proportion of the membership will terminate each year. This will allow the Board to make systematic changes in the Editorial Staff from time to time, thus bringing to the service of the Journal new interests and new points of view. While this plan has not yet been put into operation, it probably will be initiated at the next annual election of officers for the Journal.

B. S. MEYER, *Secretary*,
Administrative Board of the Ohio Journal of Science.

NOTE.

With the present volume the writer terminates his service in the editorial management of the Journal and is pleased to know that it will be in the hands of Dr. Snyder, whose services as associate editor have been of great assistance during the past year. The *Ohio Journal of Science* and its predecessor, the *Ohio Naturalist*, have been objects of continuous interest from the inception thirty-two years ago and the three years past during which I have served as editor have brought many delightful associations. Naturally, the future of the Journal will be watched with interest and its successes noted with sincere pleasure.

HERBERT OSBORN.

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